REPORT ON BEST PRACTICES TO INTRODUCE GREEN EDUCATION AT SCHOOL

BOOSTING GREEN EDUCATION

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INTRODUCTION

Boosting Green Education at School is a project funded by the Erasmus Plus programme, aiming to **promote green and environmental education at school**.

The project stems from the need to respond, on one hand, to the demands of young people who are increasingly claiming their **rights to ensure a better-preserved world** for themselves and future generations. On the other, it addresses the need for an education system that is more attentive to **sustainability and environmental protection issues** and better prepared to play a central role in educating future generations to be aware and caring **eco-citizens**.

In fact, despite the widespread recognition of the importance of **Environmental Education**, many difficulties and uncertainties persist regarding how to integrate it into school programmes, and teachers themselves need good training to learn innovative ways and methodologies to incorporate it into curricula.

Starting from this background, the purpose of the project is to create an **exchange of best practices on environmental education activities**, between high schools with students aged 14-18 and scientific organizations.

The project is implemented on an **international level**, as the issues addressed have a global dimension. The problems affecting the environment are not a private matter, and only by starting locally, it is possible to achieve a **global impact**. Hence the importance of exchanging practices from **EU countries**, comparing differences, strengthening methodologies, and making the results and outputs created during the project available to the whole of Europe.

The partnership, coordinated by **Euphoria Net**, consists of four high schools (**Tartu Jaan Poska Gümnaasium** – Estonia; **Larissa Music High School** – Greece; **Vittoria Colonna High School** – Italy; and **Albert Einstein Institute** – Spain) and four scientific organizations (**Science Centre AHHAA** – Estonia; **Digital Idea** – Greece; **The Science Zone** – Italy; and **Descubre Foundation** – Spain).

The **main objectives** of the Boosting Green Education at School project are:

- To prepare teachers to **include and integrate Environmental Education at school** and develop their competencies, skills, and methodologies in the development of practical and interactive activities that stimulate imagination and foster innovative thinking.
- To **exchange practices between formal and non-formal education** (schools and scientific organizations).
- To **promote an interdisciplinary STEM-related approach** when incorporating Environmental Education into school programmes.
- To **make students more enthusiastic and engaged in learning STEM** subjects and develop their skills, such as critical and creative thinking, civic skills, and the ability to make interconnections between social, ecological, economic, and political issues.
- To **enhance experiential learning outside the classroom** to enable students to make connections and apply their learning in the real world.

All partners provide their knowledge and expertise to develop **new experimental didactic activities focused on sustainable development and environmental education** that addressed a specific environmental and climate problem (human pollution, water pollution, climate change, etc.) from an **experimental scientific point of view**, using information from scientific publications and through the implementation of replicable experiments.

Through the organization of **four training activities** (one in each country), the partners shared best practices and compare environmental education methodologies between teachers and experts of scientific organizations. As a result, **20 activities are developed** to help teachers to engage students with practical STEM lessons focused on real-world challenges in the natural environment. For each environmental issue, scientific organizations propose an experiment to better understand the problem and its implications and produce **activity sheets with step-by-step procedures and guidelines** to help teachers to replicate these experiments and laboratories at school.

Moreover, students from the partner schools involved in the project realized **video tutorials** explaining and replicating all the activities proposed by the scientific organizations, which are posted on the **project's YouTube channel**: https://www.youtube.com/boostingscience.

The purpose of this Report is precisely to **collect all these activity sheets and make them available to all and easily replicable in the classroom**, continuously engaging students with hands-on science and facilitating the learning process and the development of their ecological awareness and green skills. Through sharing these good practices, the project wants to **increase awareness on environmental and climate issues** and **support teachers in introducing environmental education at school** to form aware and responsible citizens.

ENVIRONMENTAL EDUCATION: A DEFINITION

Now more than ever, heat waves, extreme weather events, droughts, and floods clearly show the **seriousness of climate change** and the need to implement all possible measures for environmental protection and sustainability.

School is the place where tomorrow's citizens learn, so **it is important to introduce Environmental Education into the school programmes**. There is an urgent need to teach young people respect for the environment, how to protect it, which energy sources are renewable and non-renewable, how to waste fewer resources, etc., making them citizens who care about the good of the community.

Even **UNESCO** recognizes that Environment Education has a key role to make citizens and communities more responsible and aware of environmental issues and good land governance. The teaching of Environmental Education at school aims to **raise students' awareness of the climate change crisis** and its consequences, making them develop a new way of thinking about the concept of the environment and how to better relate to it.

But this new discipline is not simply concerned with the study of the natural environment: it represents also a **concrete action aimed at promoting positive changes in people's attitudes and behaviour**, both at an individual and community level, and the active and decisive participation of individuals to help respond to environmental problems.

In fact, Environmental Education in schools is crucial to **spark concrete positive changes** that fuel young people's awareness and involvement in building a greener future. The aim is to instill in the new generations the awareness that the planet's resources are limited and that it is necessary to **reshape the relationship between citizens and the environment**, learning to respect and preserve nature and its resources and to avoid exploiting them indiscriminately.

It is a process through which individuals explore and obtain a deeper understanding of environmental issues; think about **how to solve these problems**; develop **new skills** to make informed and responsible decisions; take concrete action to improve the environment.

In summary, **Environmental Education** focuses on the development of:

- **Knowledge**, **understanding**, **awareness**, and **sensitivity** to the environment and environmental problems.
- Attitudes of **concern** for the environment and **motivation** to improve or preserve environmental quality.
- **Skills** to identify and help **resolve** environmental challenges.
- **Participation** in activities that lead to the **resolution** of environmental challenges for a more environmentally aware and participatory **citizenship**.

To best implement Environmental Education in schools, it is necessary at the same time to **train and prepare teachers** on the right way to teach these topics and engage students. For this reason, the Boosting Green Education project also focuses on preparing teachers on **best practices and teaching methodologies** on climate change, biodiversity, and sustainability and on how to integrate this new discipline into the school programmes.

SCHOOL ENVIRONMENTAL EDUCATION IN PARTNERS COUNTRIES

ESTONIA

Since 2002, the Estonian national curricula have included the cross-cutting theme **"The environment and sustainable development"**. Contributing to high-quality environmental education is one of the priorities of the Ministry of the Environment and its sub-agencies, in cooperation with environmental education centres and the Ministry of Education and Research, as well as universities.

In order to increase environmental awareness and enhance the work in the field of environmental education, the Minister of the Environment and the Minister of Education and Research signed a **memorandum of joint activities** on 31 March 2017. Its operational programme, the environmental education and awareness action plan 2019–2022, was adopted in October 2018.

The latter provides **guidelines** in the form of both existing so-called traditional activities as well as new activities, from assessing the quality of environmental education and cooperation with schools and local authorities to campaigns. Among other things, the action plan states that environmental awareness can only be increased through **reliable**, **up-to-date**, and **clearly presented environmental information** and **environmentally conscious options**.

The **Estonian Environmental Education Association** plays an important role in fulfilling the action plan, contributing to the coordination of a network of environmental education centres that is unique in the world: there are more than **150 environmental education centres** in Estonia, including those managed by the Environmental Board and the State Forest Management Centre, organising trainings for its members, and conducting quality assessments on environmental education.

A good foundation for effective environmental education is also the fact that our national curricula have included the cross-cutting theme "The environment and sustainable development" since 2002, the aim of which is to support the learner’s development into a citizen who understands and preserves the environment.

In addition, the **Environmental Investment Centre** (EIC) contributes to environmental education by supporting, among other things, the environmental education visits of kindergartens and school groups.

All this provides a solid basis for nature education. It is important to make effective use of all this by integrating different thematic areas and creating meaning, because **only a strong education can create a sense of nature**, **the ability to see connections**, and **the will to make environmentally conscious decisions**. Therefore, we go by the "how" question here – how to do all this, how to develop a science-based systematic point of view, and how to create real-life connections and speak to the learner through teaching.

ITALY

Environmental impact and sustainable development are increasingly present in the Italian school curriculum in the last year. This presence, however, is **not yet systematic and widespread**. In order to understand why, it needs to consider the large autonomy of teachers in Italy and the absence of checks on their work beyond the formal correctness of their administrative reports. Nevertheless, references to “green education” are more and more frequent for various reasons that will be briefly explained.

The first reason is the implementation, in recent years, of the subject of **Citizenship Education** (Educazione Civica) in every year of the Italian curriculum. All teachers working with the same class are now required to deliver a few hours of Citizenship, whatever their curricular subject may be, so that students are taught 33 hours of Citizenship in the whole academic year. Many schools have chosen the **2030 Agenda** and particularly **the issue of sustainable development** as one of their modules for the teaching of Citizenship.

State Exam reform is another recent change that has facilitated the widespread exploration of environment related topics. Students in high school are now expected to sustain a multi-disciplinary and cross-curricular oral examination to graduate. This means that they need to be equipped with a range of cross-curricular topics that may be used to organise their talk. **Environment issues are very often chosen for this purpose**.

Science textbooks and curricula are also integrating more and more environmental issues: **teachers of Science related subjects can now choose from a wide range of resources** designed by publishers. This makes it more likely that students in all grades of school will engage with these issues.

Finally, **students themselves are becoming increasingly aware of the challenges of sustainability**. The “Fridays for Future” movement has involved a huge number of high school students in protests and demonstrations aiming to put pressure on the Italian Government and on European Institutions to do more to tackle climate change. This makes it natural and easy to confront this issue in the classroom, where teachers of different subjects can give their contribution to enable students to **deepen their understanding of the issue** from a scientific, historical, political, and economic point of view.

An interesting development of Green Education is the tendency of some Italian schools to engage in a reflection on **how to make a practical impact** as a school community. This might include a review of the way in which the school collects and disposed of waste or the planning of active actions with students to tackle environmental issues within the local community.

Despite all these positive developments, **some important weaknesses persist** in the way “green” topics are delivered in Italian schools.

Among them, we see a **lack of consistency** across the school system and even within the same school. Some students are exposed to a wide range of stimuli on the environment and engaged in meaningful discussions about what can be done to improve the situation, others might never approach the issue in a whole academic year. This could be due to the demand for curricular subjects and the lack of specific training for teachers. Projects like **“Boosting Green Education at Schools” can make a difference in students’ experience** by providing teachers with a deeper insight into “green” topics.

Another weakness is the **lack of practical resources and laboratory practices** to teach about this topic. This favors a broadly theoretical approach that is unlikely to engage students. Developing and sharing **laboratory practices** focused on “green” issues can be a powerful way to improve the effectiveness of teaching. The sharing and dissemination of such practice is a core feature of the project “Boosting Green Education at Schools”.

In this project, after teachers meet and train together in LTTs, students are involved in **trialling the experiments** and in **producing videos** for public dissemination of the work. This maximises the impact of the project in the school involved and make it more likely that students' produced materials will make an impact on students and schools outside of the project.

SPAIN

In Spain, good environmental practices are worked from very different points of view, but one that seems especially important to us is that of education.
The new **LOMLOE educational law** that entered into force last year includes these good environmental practices from its statement of reasons, recognizing sustainable development as one of the fundamental axes of the law. The others are children's rights, gender equality, personalization of learning, and digital competence.

Article 1 on the principles that guide the law includes "Education for ecological transition with criteria of social justice as a contribution to environmental, social and economic sustainability". In title IV, the law explains that "The educational system cannot be oblivious to the challenges posed by climate change on the planet, educational centers must become a place of custody and care of our environment".

In the general principles, article 110 is reformulated to include sustainability and relations with the environment. This article highlights the **need for coordination between administrations** to promote and guarantee nothing less than:

- the culture of environmental sustainability
- social cooperation to protect biodiversity
- the sustainability of the centers
- its relationship with the natural environment
- their adaptation to the consequences of climate change
- safe school roads
- sustainable commuting

Regarding the curriculum of the different educational levels, the law speaks of **transversality** when working on education for responsible consumption and sustainable development and then to include sustainable development in the center's educational project. The LOMLOE leaves an open door here so that each center can expand this education for sustainability as much as it wishes.

On the other hand, Education for sustainable development, world citizenship and the 2030 Agenda will be included in the training processes and access to the teaching function. It is an advance that the **necessary and urgent training of teachers** is contemplated in all these aspects and especially in the SDGs (Sustainable Development Goals).

At regional level, in Andalucía, good environmental practices in schools are developed through the **ALDEA programme**, Environmental Education Programme for the Educational Community, a Programme for Educational Innovation that aims to promote the integrated development of environmental education initiatives in the face of the current climate emergency. The **connection with nature and the re-naturalization of spaces**, climate change, sustainable development and the relationship between human beings and their social and natural environment (eco-social competence) will be the backbone of the development of any line of intervention.

The lines of intervention of the ALDEA programme are as follows:

- **Conservation and improvement of biodiversity**: the aim is to promote ecological awareness and the transmission of attitudes of respect, care and enjoyment of wild birds and their habitats, based on information, awareness and active participation. On the other hand, the aim is to inform the different participating groups about activities linked to the protection of the natural environment, sustainable development and green employment.
- **Eco-gardens**: the aim is to promote ecological awareness and the transmission of attitudes of respect and care for the environment, using the school Eco-gardens as a first-rate educational resource to reinforce curricular content and to transmit to students the importance of productive techniques with food, in relation to natural cycles and respect for the environment.
- **Floral ecosystems and wild flora**: the aim is to promote ecological awareness and the transmission of attitudes of respect, care and enjoyment of the wild flora of forest ecosystems, based on information, awareness and active participation. It aims to promote research into the vegetation of our immediate environment and techniques for the defence, restoration and conservation of the flora and associated habitats, as well as forest ecosystems. On the other hand, the aim is to raise awareness of those activities linked to the sustainable use of the forest environment, sustainable development and green employment, promoting and publicising those initiatives, companies and local markets that have traditionally made sustainable use of forest resources.
- **Impact of climate change on the natural and social environment**: the aim is to promote awareness and awareness of the socio-environmental problems of climate change. It also aims to promote personal and collective involvement, encouraging energy-saving and environmentally friendly behaviour, all with the aim of carrying out actions that involve an effective reduction of greenhouse gas (GHG) emissions into the atmosphere and adaptation to new climate scenarios, applying good environmental practices.

- **Natural environment and marine environment**: the aim is to transmit the social, economic and cultural benefits of the conservation and protection of coastal habitats through information, awareness-raising, sensitisation and active participation. On the other hand, it aims to encourage research into the wild flora and fauna of the immediate environment and techniques for the defence, restoration and conservation of the coastline and to promote sustainable habits related to the conservation of the coastline in those associations and groups in the Andalusian coastal environment. At the same time, the aim is to raise awareness of those activities linked to the protection of the natural environment, sustainable development and green employment.
- **"Recapacicla"**, education for circularity: the aim is to promote ecological awareness and the transmission of attitudes of reuse, recycling and waste awareness to the entire educational community.

At the level of our school, good environmental practices are included in the school's Educational Project. We highlight the following actions. In our center, we are committed to **promoting an education in which all aspects related to the natural environment**, **its future and the behavior of students are integrated to favor the sustainability of the environment**. That is why we are evaluating different projects for their implementation.

Among them, we highlight the following.
Bicycle racks will be provided to increase the number of students and teachers who use sustainable means and avoid the use of transport that uses fossil fuels.
An **ecological wall** will be created in one of the buildings of our center. This project will be done in collaboration with the installation and maintenance department. It consists of installing a support so that the climbing plants can support themselves and can cover the wall on which they will be installed. With this, we also would be able to reduce the temperature of this space.
It is also planned to **plant trees** to help lower the temperature of the environment and increase the concentration of oxygen.
For the same purpose, we also have a **school garden**. The garden will promote sustainable education. In addition, a natural diet is promoted without the need for processed foods.

GREECE

In the Greek educational system, the field of Environmental Education (EE) unofficially started in the 80s. Beginning in the 90s, the framework to promote EE in formal education was established, with teachers integrating EE into their teaching on a **voluntary basis**. In tertiary education, there are relevant optional courses included in Early Childhood and Primary Education Departments. There are also M.Ed courses for in-service teachers. A top-rated institution in Greece is the **network of Centres of Environmental Education**, which operate short-term programs for students and local communities across the country. NGOs also play an active role in supporting EE in K-12 education.

Environmental Education (EE) was officially introduced in Greece with a law in 1990 for secondary education and in 1991 for primary education. This legislation stated that the aim of EE is: "for students to become aware of their relation to the natural and social environment, of the problems connected to it, and to take action so that they contribute to the general effort of dealing with them". To meet these needs, the Ministry of Education compiled a **Cross-Curricular Programme Framework of Studies** to give directions for project implementation. There was also a curriculum for the Environment and Sustainability compiled in 2010, but it has not been implemented.

Although EE is not a part of the Ministry of Education's formal K-12 curriculum, teachers can still implement EE on a voluntary basis in the following framework:

- In **kindergarten**, EE can be integrated within formal programs in connection to the curriculum in subjects such as Greek language, math, ICT, art, etc.
- In **primary school**, grades 1-4, EE programs can be applied during project time, for example, teaching hours intended for cross-curricular projects. In grades 5-6, EE is introduced through formal subject curricula, such as Greek language, math, ICT, art, geography, foreign languages, and more.
- In **secondary education**, with the voluntary participation of teachers, students, and parental consent, programs such as after-school clubs often take the lead in implementing EE activities and instruction.

Teachers submit their EE program outline to the EE coordinator of each Education Directorate and programs are approved based on their **educational and scientific merit**. Teachers have the right to choose or co-decide with their students, their project topic in relation to the local environment, the local needs, and any immediate needs that arise (such as forest fires).

This approach in **experiential learning** focuses on problem-solving and project- and inquiry-based learning. The duration of these programs is typically 2 months and the outcomes are the development of student-directed action with a particular focus on civic engagement.

Schools can also become members of **EE networks and communities of practice**, which foster support for members in the EE community

In addition to school programs, there are also **Centres of Environmental Education** in each of the 52 prefectures in Greece. These centers implement one- to two-day EE programs for K-12 students. These programs consist of local field trips to forests, beaches, wetlands, cities, and cultural and archaeological sites. The Centres of Environmental Education also consider sustainable development when choosing **field trip destinations**. Teaching staff includes both primary and secondary teachers of all subjects with a special EE background. Teachers get organizational support from municipalities and financial support from European Union (EU) funds. Due to organizational and financial support, these programs are free for students.

Several NGOs and **universities** collaborate with program coordinators and Centers of EE to provide professional development to teachers. Opportunities for professional development in EE often include **seminars and workshops** at local or national Centers of Environmental Education.

ACTIVITY SHEETS

The **different approaches of the organisations** involved in the project are being enriching and enthusing for the teachers involved and for their students.

We find that one aspect is especially likely to make an impact in dissemination: **the experiments that we are learning, and sharing are mostly accessible to any teacher or any school**, regardless of their resources.

This means that **anyone can implement them** even if their school does not have a laboratory, a technician, access to chemical or technical instruments etc. In a situation where school access to funding and resources is very unequal across the EU and within individual member States, **disseminating ideas and tools** that can be used by everyone increases greatly the possibility to make an impact.

It also **encourages teachers of scientific and non-scientific subjects to integrate experimental work** in their lessons.

Each sheet contains the instrumentation (**MATERIALS AND INSTRUMENTS**) and the procedure (**TUTORIAL**) to carry out each experiment, with technical tips to best carry out the experience (**TIPS AND TRICKS**). In addition to this, in the **LEARNING SCENARIO** section, there are practical tips for organizing the class so that each working group can work independently and everyone can be a protagonist in the experiment by performing a part of it (Key Point 2).
In addition, the **POSSIBLE QUESTIONS** section contains questions that can be the starting point of the IBSE lab or can be asked at the end of the lab to interest students even more in the subject matter and to give more value to the work they have done (Key Point 4). The **FURTHER INFORMATION** section is the section where there are links to websites that allow further study of the lab just performed, contextualizing it in a broader discipline or relating it to actual natural phenomena explained in the experiment just performed. The **QR codes** in the **LET'S TRY IT** section allow you to view videos of each experiment addressed in the project.

These videos are a great tool for educators/teachers, but we recommend not showing them to students before conducting the experiment to allow them to explore freely.

PHOTOSYNTHESIS IN A JAR

SUBJECT
ENVIRONMENTAL SCIENCE

TOPICS
#ECOSYSTEMS #PHOTOSYNTHESIS #FOREST LOSS #CLIMATE CHANGE #OXYGEN PRODUCTION #LIFEANDBIOSPHERE

OBJECTIVES

- Learn how plants photosynthesize

- Learn about deforestation and its effects on climate and ecosystems

LEARNING SCENARIO

Groups: 3 different groups of 3 students, one with a transparent funnel and a plant; one with transparent funnel and no plant; one with non-transparent funnel and a plant. Optional – use sparkling water as a control group.

Time needed: 60 minutes

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

3 transparent jars/beakers
2 transparent funnels with a long neck (that must fit in the jar completely)
1 non-transparent funnel with a long neck (that must fit in the jar completely)
3 test tubes
Water (to fill 3 bottles and 3 test tubes)
Elodea canadensis water plants (to fill up 2 funnels), available in aquarium shops
Baking soda (to speed up the process)
Sunlight / UV light
Lighter
long wooden grill stick

TIPS AND TRICKS

Carefully lift up the test tube up (from the water) to the level of the water (do not lift it out of the water, see the picture).
Cover the top of the tube with your thumb so the air will not come out (see the picture). Do it quickly!
Light up the grill stick (with the help of a team-mate). Do it carefully, fire is dangerous!
Turn the tube upside down (so the gas goes up) and carefully release your thumb and put the burning stick into the tube. See what happens.

PHOTOSYNTHESIS IN A JAR

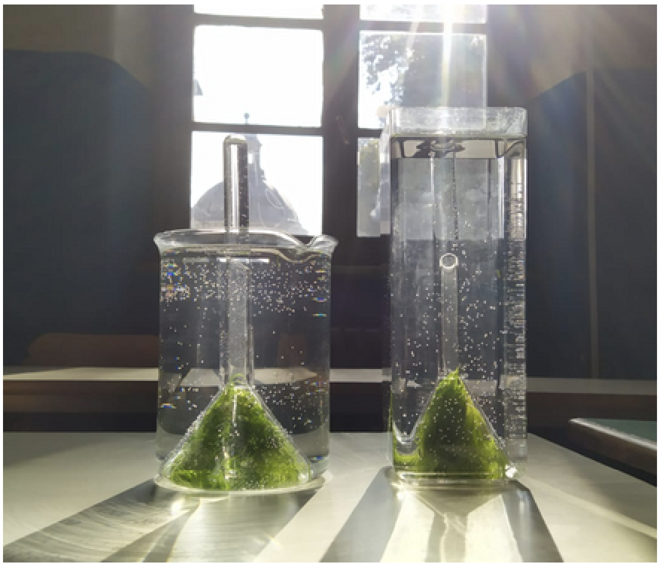
TUTORIAL

	Transparent funnel and a plant	Transparent funnel and no plant	Transparent funnel and no plant
STEP 1	Fill up the jar with wate	Fill up the jar with water	Fill up the jar with water
STEP 2	Take 3 cm pieces of plant and put them tightly in the transparent funnel (see the picture)		Take 3 cm pieces of plant and put them tightly in the non-transparent funnel (see the picture)
STEP 3	Carefully place the funnel in the jar (upside-down, see the picture)	Carefully place the funnel in the jar (upside-down, see the picture)	Carefully place the funnel in the jar (upside-down, see the picture)
STEP 4	Fill the test-tube with water and cover the top of the tube with your thumb (so that the water will not come out). Turn the tube upside down and carefully place it on the neck of the funnel (see the picture)	Fill the test-tube with water and cover the top of the tube with your thumb (so that the water will not come out). Turn the tube upside down and carefully place it on the neck of the funnel (see the picture)	Fill the test-tube with water and cover the top of the tube with your thumb (so that the water will not come out). Turn the tube upside down and carefully place it on the neck of the funnel (see the picture)
STEP 5	Place your jar in direct sunlight (if there is no sun, use a bright lamp and direct it on the jar) and leave it there for a couple of days (do not shake/move the jar)	Place your jar in direct sunlight (if there is no sun, use a bright lamp and direct it on the jar) and leave it there for a couple of days (do not shake/move the jar)	Place your jar in direct sunlight (if there is no sun, use a bright lamp and direct it on the jar) and leave it there for a couple of days (do not shake/move the jar)
STEP 6	If you want to speed up the process, add baking soda (a pinch – ¼ teaspoon)	If you want to speed up the process, add baking soda (a pinch – ¼ teaspoon)	If you want to speed up the process, add baking soda (a pinch – ¼ teaspoon)

PHOTOSYNTHESIS IN A JAR

EXPLANATION

This experiment shows plants producing oxygen from carbon dioxide, in the presence of sunlight. Water plants exposed to the sunlight use CO_2 dissolved in water and produce O_2 by photosynthesis. The O_2 builds up on the top of a test tube pushing down the water in the column. You can verify the presence of oxygen with a burning match, exploiting the fact that O_2 favors combustion.



POSSIBLE QUESTIONS

Describe in detail what you see in the jar.
Why are the bubbles forming?
How are the bubbles moving?
Describe the differences of the jars.
What is in the top of the test tubes?
How can you check if the air in the top of the tube is oxygen?
What happens with the flame (in each tube)?
How to explain why the flame changes/does not change?

FURTHER INFORMATION

https://www.youtube.com/watch?v=eET7jwJOOqA https://esdac.jrc.ec.europa.eu

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutoral created by the students of the project. Follow this link https://youtu.be/sGrrBQavEo8 or scan the QR code

LIFE IN A JAR

SUBJECT
ENVIRONMENTAL SCIENCE

TOPICS
#MICROBIOME #ECOSYSTEM #BACTERIA #BIODIVERSITY

OBJECTIVES

- Learn how to build a Winogradsky column
- Make observations on a long ongoing experiment
- Learn the interdependence of life forms on a microbial scale

LEARNING SCENARIO

Groups: groups of 4-5 students. Part of the lab is outside, part in the classroom

Time needed: 60 minutes to collect natural material, 60 minutes to prepare the columns and at least 8 weeks to collect results.

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

Mud: from the bottom of a lake or river or a pond (take photo of that)
Water: from the same place where the mud is collected, if it is not possible tap water.
Material to enrich mud: a carbon source such as newspaper or egg-shells, and a sulfur source such as chalk or egg yolk, an iron source as a coin, salt.
At least 4 identical containers: a glass tube or transparent container, (best if rigid) that will contain the mixture of mud and water, about 30 cm tall and 5 cm diameter but dimensions are not critical.
Tools for digging the mud collect it and insert it into the bottle: showel, buket, gloves, smaller container to mix mud and materials, funnel.
Instruments to record data: paper, pen, phone camera.

TIPS AND TRICKS

To maintain safe protocol, follow these simple cautionary steps, to limit growth of fungi and release of spores:
- Keep the mixture in the columns moist with a layer of water on top
- Make certain there is little to no organic material on top of the mixture
- Do not breathe in directly over an uncovered column.
- Wear gloves when handling the sediment mixture and columns
- Columns must be stored with the lid loose. Gases produced by microorganisms can build up quickly and must be allowed to escape to avoid a build-up of pressure that may lead to column explosion. MATERIAL INSIDE THE COLUMN CAN SMELL REALLY BAD.

LIFE IN A JAR

TUTORIAL

	Part 1 – Collect the sediment sample
STEP 1	Identify a sediment source in your area. Anywhere with dirt and water is appropriate, such as a stream, creek, marsh, pond, bay, beach sand, a backyard puddle
STEP 2	Take photographs of your sample site
STEP 3	Collect enough sediment to fill ¾ of your container in the bucket. The sample should be wet, including some additional water from the sample site
	Part 2 – Assemble the Winogradsky columns
STEP 4	Separate mud in 4 equal parts using four different disposable containers, each one of this mud will be part of a different column (you can add different “enrichment” but always remember to create a control column, with just mud and water)
STEP 5	Label the columns with a marker or a post-it
STEP 6	Assemble the Winogradsky Columns: 1) For the “carbon” column: Add some shredded paper (loosely packed and not plastified) to the sediment and mix, paper containing cellulose, a source of carbon. 2) For the “sulfur” column: Add the yolk of an egg to the sediment and mix, egg yolk is a source of calcium sulfate. 3) For the “carbon and sulfur” column: Add both enrichment and mix. 4) For the “control” column: Do not add anything to the mud.
STEP 7	Mix each of the samples thoroughly. Try to remove any large debris such as leaves, rocks, or sticks. Slowly mix in water (either water that you collected or tap water) until the mixture has the consistency of a mud shake.
STEP 8	Fill your different columns until 3/4 of the column's length. Half fill the remaining space with collected or tap water, leaving some air in the upper part
STEP 9	Tap the column to release any trapped air in the mud, loosely close the column to avoid water evaporation and to prevent the material from falling due to accidental impact.
STEP 10	Record your visual observations every week, for 6-8 weeks and take pictures of your experiment, always shoot in the same light condition

LIFE IN A JAR

EXPLANATION

This experiment shows that water and soil contain a multitude of microorganisms that a combination of microbial metabolism and physical parameters (such as light availability and diffusion) can create a rich stratified ecosystem. You can recognize your bacterial population by their colour,using Tab.1.

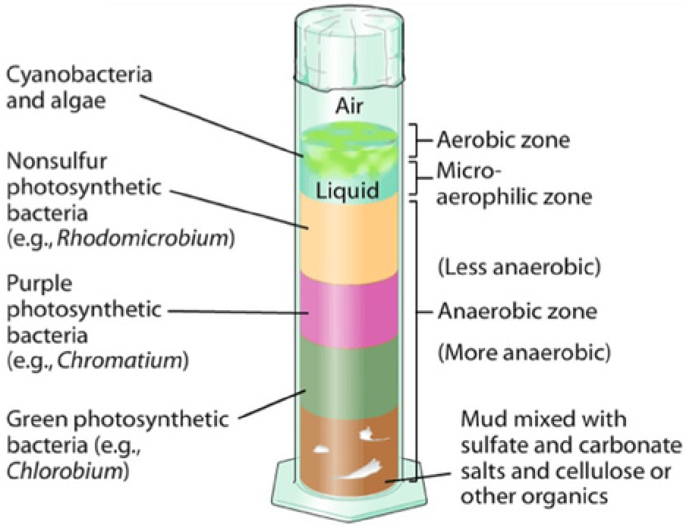
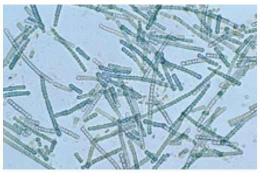
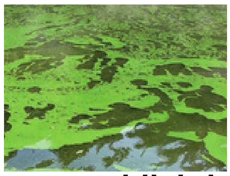
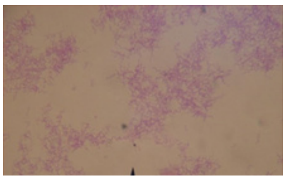
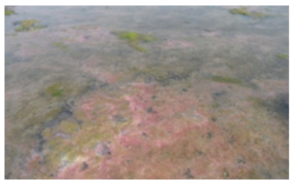
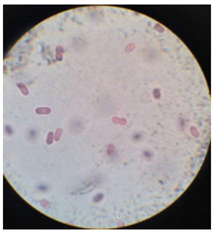
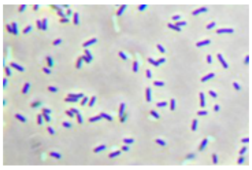
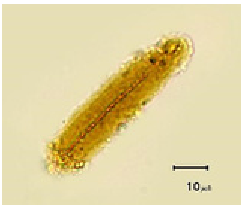
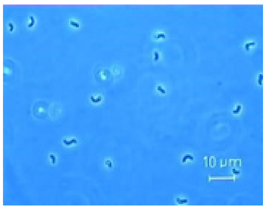
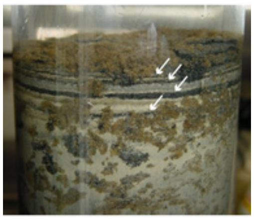
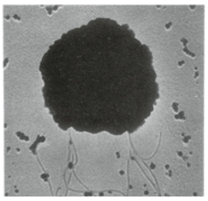
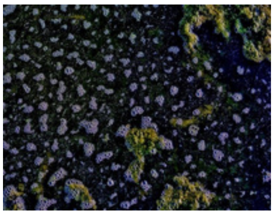


TABLE 1

Position in column	Functional group	Organism Examples (microscope view)	Visual indicator
TOP	Photosynthesizers	 Cyanobacteria	 Green or reddish-brown layer. Sometimes bubbles of oxygen.
MIDDLE	Nonphotosynthetic sulfur oxidizers	 Beggiatoa, Thiobacilus	 White layer
	Purple nonsulfur bacteria	 Rhodomicrobium, Rhodospirilum, Rhodopseuodmonas	 Red, purple, orange, or brown layer

LIFE IN A JAR

TABLE 1

Position in column	Functional group	Organism Examples (microscope view)	Visual indicator
MIDDLE	Purple sulfur bacteria	 Chromatium	 Purple, or purple-red layer
	Green sulfur bacteria	 Chlorobium	 Green layer
	Iron-oxidizers Bacteria	 Thiobacillus ferrooxidans, Leptospirillum ferrooxidans, Mariprofundis ferrooxydans	 Red just colour
	Sulfate Reducing Bacteria	 Desulfovibrio, Desulfotomaculum, Desulfobacter, Desulfuromonas	 Black layer
	Methanogens	 Methanococcus, Methanosarcina	 Sometimes bubbles of metane. Deep black color

LIFE IN A JAR

POSSIBLE QUESTIONS

Check if stratified populations are correlated to elements cycling (es. top bacteria produce something used by bottom bacteria).
Students can manipulate variables to test microbial growth in different conditions "Which microbial populations will grow more?"

FURTHER INFORMATION

https://www.jove.com/it/v/10506/creating-winogradsky-column-method-to-enrich-microbial-species
https://publish.illinois.edu/projectmicrobe/files/2015/05/U9_L4_Resource_WinogradskyColumnProtocol.pdf
https://www.biointeractive.org/classroom-resources/winogradsky-column-microbial-ecology-bottle

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutoral created by the students of the project. Follow this link https://youtu.be/J7R1TzLglNM or scan the QR code

GLOBAL WARMING IN A BOTTLE

SUBJECT
PHYSICS OF MATTER
THERMODYNAMICS

TOPICS
#CO2
#CLIMATE CHANGE

OBJECTIVES

- Learn what global warming is

- Realize the impact of their lifestyle on the environment

LEARNING SCENARIO

Groups: groups of 3 students

Time needed: 60 minutes (the first 30 minutes for the preparation of the experiment, the other for the data collection)

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

Electronic thermometers with a 0,1ºC sensibility

A can containing CO2 with a pressure reducer and plastic pipes (you can substitute the CO2 with a chemical reaction between vinegar and bicarbonate)

Electric incandescent bulb (its light must have a spectrum like sunlight)

2 glass flasks, identical, 2l of volume, with airtight cap

Timer

Sticky gum

A pair of stoppers

TIPS AND TRICKS

Be aware of the pressure of the gas in the can, open the valve slowly.
When you fill the flask you have to leave one of the holes open otherwise the cap will pop off because of the increasing of pressure inside. If you don't use professional flask you have to be extremely careful because high pressure could break the glass.
If you want to be ensure the flask if full of CO2 you can light a match, put it in the flask and watch the flame die.
You can use sunlight instead of an incandescent light bulb, but you can not use a laser or al led (choose carefully the light source).

GLOBAL WARMING IN A BOTTLE

PREPARATION

You have to make a hole in the caps of the flasks, that has to be big enough to put the sensor of the thermometer inside it.

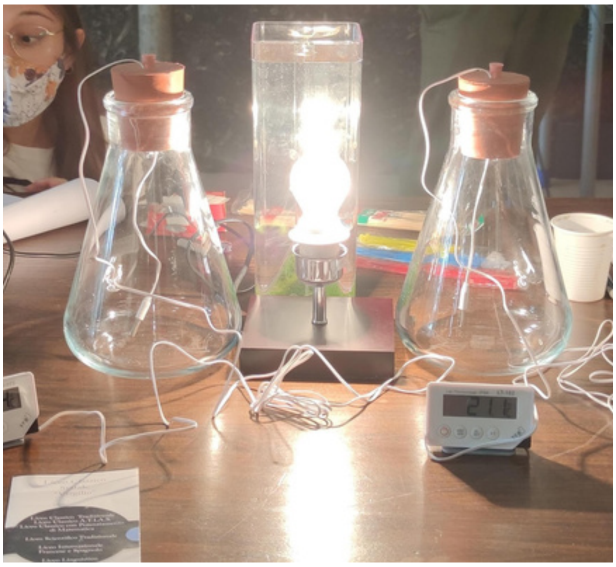
TUTORIAL

STEP 1	Insert the thermometers in the flasks and wait until the temperature stabilizes
STEP 2	Fill one of the flasks with CO_2 using the pressure reducer, after this the temperature might change, but it is not a problem
STEP 3	Close all the holes in the flasks using stoppers and sticky gum
STEP 4	Put the flasks at the same distance from the lamp and turn it on
STEP 5	Read and write down the temperature of the flasks every 60 seconds for at least 15 minutes
STEP 6	Ask the student to analyze the results maybe plotting a graph of temperature vs time

GLOBAL WARMING IN A BOTTLE

EXPLANATION

This experiment shows that the increase of CO_2 contributes to substantial rise of temperature, in a glass flask as in the atmosphere. The molecules that form the atmosphere has different chemical and physical properties, so they react differently to light exposure. Green-house gases absorb and emit infrared light and so they get hot faster and cold slower.



POSSIBLE QUESTIONS

How do you think the link between a high concentration of CO_2 and increasing of temperature affects temperature on Earth?
How do you think your behaviour, the food you eat, the way of transportation you use affect the CO_2 emissions?
What can we do for the environment?
If you have time you can observe the reverse process of cooling, do the gases cool down in the same way?
You can substitute the CO_2 with a chemical reaction between vinegar and bicarbonate

FURTHER INFORMATION

https://www.ventusky.com/ - https://earth.nullschool.net/
https://app.electricitymap.org/map?wind=false&solar=false
https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases - https://compostrevolution.com.au/
https://climate.nasa.gov/ https://www.ipcc.ch/
https://www.ted.com/talks/gavin_schmidt_the_emergent_patterns_of_climate_change#t-2113 - https://www.youtube.com/watch?v=64R2MYUt394

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutoral created by the students of the project. Follow this link
https://youtu.be/ShvVDXtMZEo or scan the QR code

OCEAN ACIDIFICATION

SUBSCT

SUBJECT
CHEMISTRY
BIOLOGY

TOPICS
#PH #CARBONATES AND ACIDS
#METALS AND NON-METALS
#ECOSYSTEMS #HOMEOSTASIS #EVOLUTION

OBJECTIVES

- Understand how the level of carbon dioxide in the atmosphere affects the pH of the oceans

- Learn to measure and compare the pH of different solutions

- Learn to collect qualitative and quantitative data

LEARNING SCENARIO

Groups: groups of 3 students

Time needed: 60 minutes but the discussion can take as much as needed/chosen

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

Two jars with lids and **shot glasses**

Small paper cups and **water**

Bromocresol blue pH indicator/red cabbage extract

Vinegar/lemon juice and **sodium bicarbonate**

Sodium hydroxide

Hydrochloric acid

Universal indicator paper and/or pH-meter (more accurate)

Masking tape

Protective gloves

TIPS AND TRICKS

Use gloves to handle strong acids and alkalis and Ph indicators

OCEAN ACIDIFICATION

PREPARATION

We recommend the teacher/educator to try the experiment beforehand in order to identify the quantities, jar sizes etc. that work best. The red cabbage indicator, if used, might be produced beforehand by teacher or students or it can be made on the day.

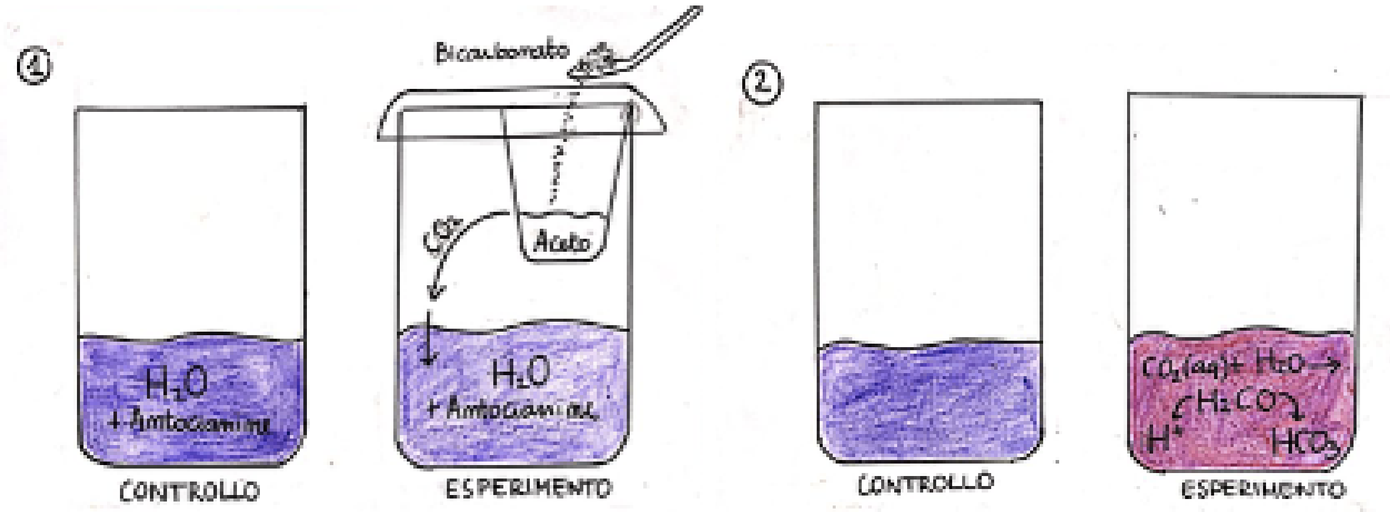
TUTORIAL

	Part 1 – A small scale model of ocean acidification (“Acidification of a glass of ocean”)
STEP 1	Add 1 ml of pH indicator to about 500 ml of water and place an equal amount of this solution in the two jars. Save some solutions for the last part of the experiment. The two jars will be placed on a white sheet of paper to better observe the colour difference.
STEP 2	Fix a small paper cup to one of the jars, as shown in the picture.1, closing the other that will act as a control, making sure that it does not touch the solution.
STEP 3	Place in the small paper cup a tablespoon of vinegar, add a teaspoon of sodium bicarbonate and close the lid quickly. Make sure that the liquid in the cup does not overflow mixing with the one in the jar.
STEP 4	Wait for a few minutes until a change in colour is observed. To make it more evident, some more sodium bicarbonate can be added.
	Part 2 – Building a pH scale and measuring pH values
STEP 5	Place an equal amount of the original solution into four shot glasses and add to each of them a small quantity of different acidic and alkaline substances. Observe and record the observed colours.
STEP 6	Use the universal indicator paper (and the pH-meter if available) to measure the pH of these solutions and the pH in two jars. Record all the results.
	Part 3 - Data collection
STEP 7	Students can use these table.1 and table.2 (or similar ones) for data collection. For a more advance/ challenging activity, students could be asked to design their own table.

OCEAN ACIDIFICATION

EXPLANATION

This experiment shows that the increase of CO2 contributes to substantial rise of temperature, in a glass flask as in the atmosphere.
The molecules that form the atmosphere has different chemical and physical properties, so they react differently to light exposure.
Green-house gases absorb and emit infrared light and so they get hot faster and cold slower.



Part 1

Solution	Colour observed	PH value
Control		
Experiment		

Tab.1

Part 2

Solution	Substance tested	Colour observed	PH value
1			
2			
3			
4			

Tab.2

OCEAN ACIDIFICATION

POSSIBLE QUESTIONS

How far the model resembles reality?

Is the ocean "healthy" and what do we mean by this?

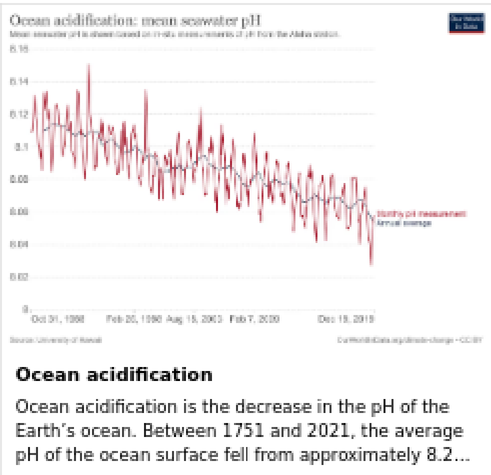
In which ways the human activities pollute the ocean? Are there any invisible pollutants?

How fast is the spread of pollutants in the oceans and how long do they remain in the ocean before being recycled?

What conditions are needed for the ocean and its living organisms to stay healthy?

Why are organisms so sensitive to the Ph?

FURTHER INFORMATION



LET'S TRY IT!

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WATER POLLUTION

SUBJECT
CHEMISTRY
BIOLOGY

TOPICS
#WATER POLLUTION #DRINKING #WATER SAFETY #WATER QUALITY PARAMETERS #FILTRATION SYSTEMS

OBJECTIVES

- Learn how to Create a functional water filtration system
- Learn how to compare different water purification methods
- Learn how to obtain safe drinking water
- Know the catastrophic effects of water pollution

LEARNING SCENARIO

Groups: groups of 4-5 students

Time needed: activity lasts 45-60 minutes (+ 48h for analysis)

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

Gloves

Paper towels for protecting the table and **chemicals** (all household chemicals are suitable, e.g. bleach; ammonia; hydrogen peroxide; ethanol)

4 glasses, 4 plastic cups for water samples**, 1 plastic bottle cut in half, poke small holes in the cap, bottle of water, paper towels, pasteur pipette or dropper or syringe**

Manure (or soil)

Thin piece of fabric (fine mesh, stocking etc)

2 spoons, wooden stick, 3 iQ BAC tests, well-water test (pH, hardness, chlorine, nitrate, nitrite), **pebbles**

TIPS AND TRICKS

In this activity we will be using substances harmful to humans.
Please keep on gloves while working with manure and chemicals. Keep everything away from mouth, nose and eyes.

BOOSTING GREEN EDUCATION

WATER POLLUTION

PREPARATION

Before the lesson, gather manure for the contaminated water. In the absence of manure, you can use soil.
Arrange the classroom so all groups are separated. Hand out all the materials needed for the filter system.
Give all the groups a bottle full of water.

TUTORIAL

STEP 1	Measure out a teaspoon of manure and mix it well into the water in the glass.
STEP 2	Gather a small sample from the unfiltered water into a plastic cup.
STEP 3	Build the basis for the filter. Take a plastic bottle, cut it in half. Take the part with the cap and poke small holes in the cap. This will be the filtering system.
STEP 4	Add the first layer of the filter system consisting of pebbles.
STEP 5	Filter the contaminated water through the filter into a glass. Mark the glass with the number of filtrations done – in this case 1. On the glass, mark the level of the liquid.
STEP 6	Gather a small sample from the first filtrate.
STEP 7	Take out the first layer of the filter and wash out the leftovers. Add the second layer of the filter system consisting of fabric.
STEP 8	Filtrate the water from the last step into a new glass. Mark the glass no 2 and mark the level of the liquid.
STEP 9	Take out the fabric layer and add paper towels to create third filtration layer. Make sure that the paper towel layer is thick enough but does not absorb all the liquid. A fitting amount would be 4 layers.
STEP 10	Filtrate liquid number 2 into a third glass. Mark it with number 3 and mark the level of the liquid. In this step the amount of liquid will decrease the most.
STEP 11	Gather a small sample of the last filtrate.
STEP 12	Add chosen chemical to the liquid which has passed all filtration layers. Please be careful to not mix chemicals and cause unwanted reactions.

WATER POLLUTION

TUTORIAL

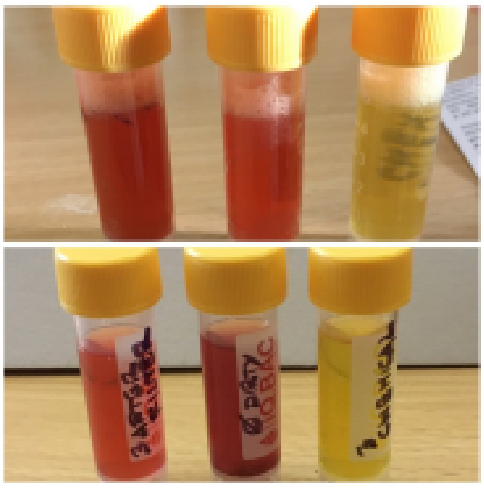
STEP 13	After mechanical and chemical filtration conduct the tests. Microbiological iQ BAC test should be done on the unfiltered contaminated water, the last sample of mechanical filtering and the chemically treated water. Bacterial test runs for 48 hours.
STEP 14	Conduct the well-water test on chemically treated water to test its safety. Mandatory tests are nitrate and nitrite test, pH test, hardness test and chlorine test.
STEP 15	Gather the numerical data and find comparison.

EXPLANATION

This experiment shows the effectiveness of filtration in water purification. The smaller the filter texture are the more pure water we will get. But if we have filters with too small textures, the flow speed decreases (according to Darcy law). Easier filtering can be done at home using regular supplies, but laboratories use filters with 0,0002 millimeter wide openings, which also remove bacteria successfully.

Good filters consist of multiple layers. In this way we get rid of as many particles as possible, at the same time the speed does not decrease significantly.

Mechanical filtering will remove visible particles, but filtering in these conditions cannot destroy bacteria. For the water to be safe, we need to remove pathogenic bacteria, for example Escherichia coli. That can be done by chemical treating. In this experiment bleach, chlorine, ammonia, hydrogen peroxide and alcohol are used to remove bacteria from water. By using some of these substances the water is microbiologically clean but not safe because it has a ph of 8.5 (undrinkable). So we could use this water for other purposes.



BOOSTING GREEN EDUCATION

WATER POLLUTION

POSSIBLE QUESTIONS

What other purposes might the water we have filtered be used for?
How do we know if this water is safe for these new purposes?

FURTHER INFORMATION

Theories of filtration (Magadh University, https://magadhuniversity.ac.in/download/econtent/pdf/Filtration_Theory%20and%20Factors%20affecting_Pharm%20Eng%20I.pdf)

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutoral created by the students of the project. Follow this link https://youtu.be/-J4J2Mmqj1g or scan the QR code

VITAMIN C AND FOOD WASTE

SUBJECT
ORGANIC CHEMISTRY

TOPICS
#VITAMINS #FOODWASTE #COLORIMETRY #LOCALFOOD #FOODNUTRITIONS #CVITAMIN #VALUEOFFOOF #FOODEDUCATION

OBJECTIVES

- Raising awareness about choosing food
- Learning to detect vitamin C in fruits and vegetables and compare the results
- Learning to value local food
- Recognize the nutritional properties of food which have a risk to be wasted
- Preventing, reducing and avoiding food waste

LEARNING SCENARIO

Groups: 2 -3 students per group

Time needed: 60 minutes

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

fruits/vegetables (each group should have 2 or 3 fruits (for example 1 local apple, 1 organic apple, 1 non-organic apple. Each group should have different fruits/vegetables)
distilled water (300 ml)
Lugol's iodine (or Lugol solution, see EXPLANATION) (1 bottle is enough for the group)
starch solution (200 ml)
juicer (for orange/lemon etc), **chopping board**, **mortar** and **pestle**
beakers (at least 200ml) (2 for each fruit)
test tubes (1 for each fruit) and **test tube rack**
pipettes or **droppers**
knife and s**poons**
kitchen scale
rubber gloves
markers, **paper** and **pen to record data**

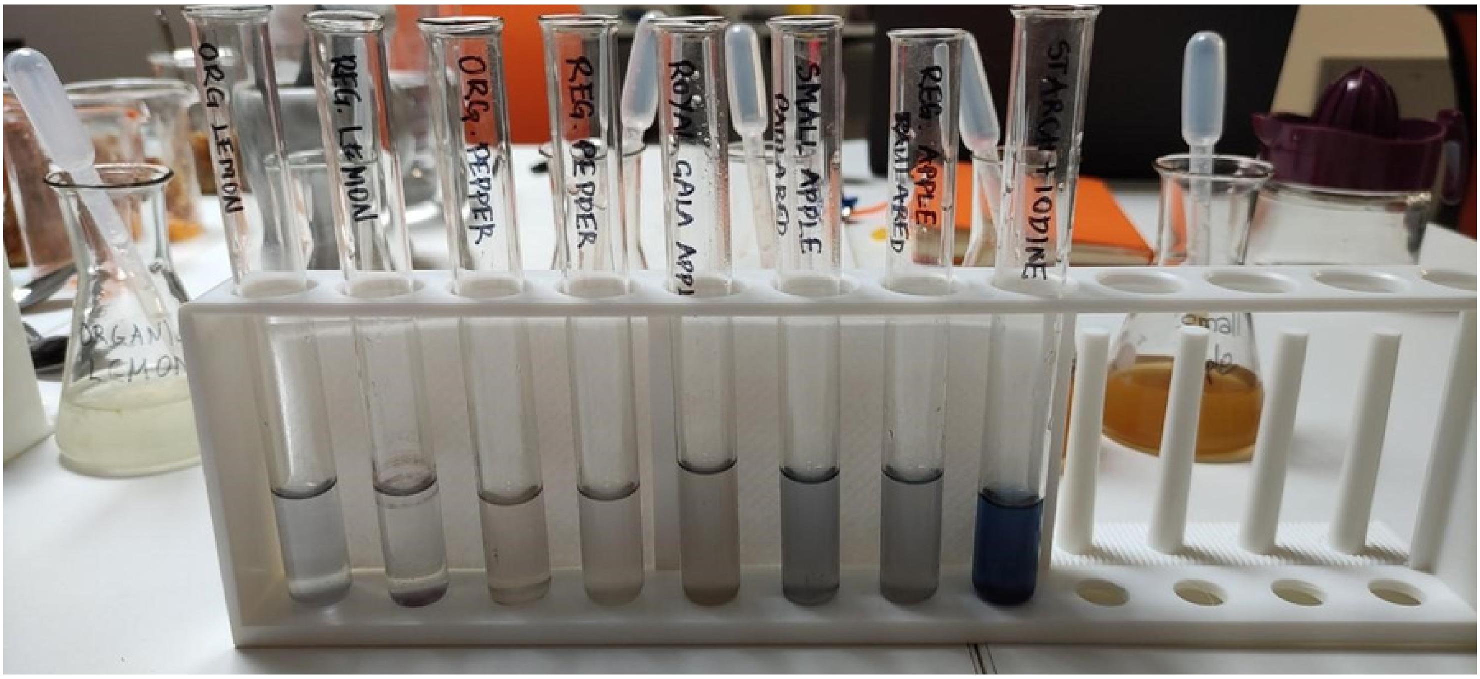
TIPS AND TRICKS

- Use gloves when handling iodine .
- Avoid using metal dishes.
- Mark the test tubes to distinguish different fruit solutions.
- You can use fruits/vegetables that you already have at home.
- If you compare different fruits and vegetables, the amount of fruit juice and water in all solutions should be equal (10 ml of fruit + 50 ml of water).

VITAMIN C AND FOOD WASTE

PREVIOUS PREPARATION (IF NECESSARY)

Prepare the starch solution. Mix 500 ml of water with 2 tablespoons of starch (corn starch, potato starch, or rice starch). Bring the mixture to boil for a few minutes until the solution turns clear and let it cool. Store in the fridge.
Find fruits/vegetables with a higher amount of vitamin C (e.g. lemon, orange, bell pepper, kiwi, etc).



VITAMIN C AND FOOD WASTE

TUTORIAL

STEP 1	Preparation of fruit/vegetable extract: Crush and grind fruit/vegetable in a mortar using a pestle. For citrus fruits use a juicer.
STEP 2	Pour ground fruit into the beaker (name the beaker before adding fruit)
STEP 3	Mix 10 g of ground fruit with 50 g of distilled water. For each solution use a separate pipette.
STEP 4	Prepare the indicator solution from starch solution and iodine: pour 100 ml of starch solution into a beaker and add a few drops of iodine until it turns dark blue/purple.
STEP 5	Stack test tubes in a rack and mark them (one test tube for each fruit sample and one extra to compare the color afterward)
STEP 6	Add 5 ml of starch/iodine solution to each test tube.
STEP 7	Carefully add fruit juice with a pipette and count the number of drops added until the color of the indicator disappears. Mix or shake each test tube in between adding drops of fruit sample. Observe the results straight away.

EXPLANATION

The reagent (water and starch, known as a starch solution) assumes an intense purple color when in contact with Lugol’s iodine. Lugol’s iodine is a hydroalcoholic yellow-brown iodine solution.
The molecule of iodine can fit perfectly into the starch helix and this interaction causes an immediate change in color, from yellow-brown to dark purple.
The reaction is reversible in presence of vitamin C. The foods containing vitamin C break up the starch-iodine complex and bring the reagents back into their initial color. Iodine is a strong oxidant that reacts with both vitamin C and starch. The greater the amount of vitamin C present, the greater the change

VITAMIN C AND FOOD WASTE

POSSIBLE QUESTIONS

Why is vitamin C important for the human body?
Why choosing local food is important?
What can we do to reduce food waste?

FURTHER INFORMATION

https://www.hsph.harvard.edu/nutritionsource/vitamins/
https://www.futurelearn.com/info/courses/biochemistry/0/steps/15315

LET'S TRY IT!

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BOOSTING GREEN EDUCATION

ECO COLUMN

SUBJECT
ENVIRONMENTAL SCIENCE

TOPICS
#ECOSYSTEMS #HABITATS #MICROHABITATS #NUTRIENT CYCLING #ENVIRONMENTAL SUSTAINABILITY #ENVIRONMENTAL EFFECTS

OBJECTIVES

- Creating an ecosystem on a small scale
- Learning how can different ecosystems look like and how are they connected.

LEARNING SCENARIO

Groups: groups of 3 students, each group needs three plastic bottles. One group should have the basic pure column (tap water, basic plant), the others can add different variables. E.g. Each group could try different types of water, different additives in the compost, etc.
Time needed: 45 minutes to explain the procedure and 45 minutes to build the column. Observations could be carried out over a period of weeks or months.

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

3 bottles (2-5 liter versions. Recommendation is 2-liter bottles)
Soil. Can be garden soil sold in gardening shops. For added experiments, regular soil from anywhere can be used to see any differences from garden soil.
Water. Regular tap water available will work for the experiment. Water from different sources and with different properties (ionized water, distilled water) can be used for further experiments.
Small gravel or **pebbles** to use as drainage.
Water plant or several. Ex. Limnophile, Cryptocoryne, and Anubias can be purchased from an aquarium shop.
Plant seeds. Many different plants can be used in this experiment. For fast growth grass seeds are recommended. For slower growth, different vegetable seeds can be used (legumes, salads, and so on)
Scissors and/or **cutting knife**
See-through plastic tape (1 roll)
Hammer and a **small nail**
Cutting board. To cut on and hammer the nail safely
Plant matter for decomposition in compost level. Fallen leaves, twigs, vegetable leftovers, and similar things are recommended.

BOOSTING GREEN EDUCATION

ECO COLUMN

OPTIONAL MATERIALS AND INSTRUMENTS

Compost soil. If available, use a compost layer as it has necessary microorganisms for decomposition and might already contain earthworms that can help in decomposition.

Computer. For data collection and analysis.

Data collection. **Soil** and **water probes** or/and **testing kits** (temperature, pH, NPK fertility)

TIPS AND TRICKS

You can turn the experiment into a terrarium by placing the top part of bottle 1 on top of bottle 3 and taping them together.

Use straight-sided bottles (not curved).

Scissors are better for cutting the bottles than a knife.

Don’t use big twigs that have to be cut with a knife, use leaves, and smaller twigs instead.

Use a small spade for gardening to put gravel into the bottles.

Before taping together the bottles, stabilize them by placing small pieces of tape on the sides to fasten the bottles together.

PREPARATION

Wash the gravel under running water.

Take three bottles and number them 1-3 using a waterproof marker.

Cut the upper part off of bottle number 1.

Cut the lower part off of bottles number 2 and 3.

Bottles 1 and 2 should be as long as possible, bottle 3 can be as long as needed.

Screw the caps off of bottles 2 and 3 and carefully make multiple holes in the caps using a nail, a wooden board, and a hammer.

Screw the caps back on.

ECO COLUMN

TUTORIAL

Bottle 1 (bottom layer - the aquatic layer):

Put about 2 cm of gravel to the bottom of bottle 1.
Add the water plant to the bottle.
Fill in the bottle with gravel around the plant so that it sits comfortably in the gravel.
Pour water onto the plant so that it is fully soaked in the water.

Bottle 2 (middle layer - the compost layer):

Take the bottom half of bottle 2 and put some earthworms in compost into it.
Add some soil to the earthworms.
Peel and cut some fruit or vegetable and add it to the mixture. Acidic fruits are not recommended.
Cut small twigs into pieces and add them to the mixture.
Stir the mixture with a spoon.
Put bottle 2, upside down, on top of bottle 1.
Add some gravel to bottle 2.
Pour the mixture of earthworms, soil, and fruit into bottle 2.
Fasten bottle 1 and bottle 2 together using some tape.

Bottle 3 (top layer - the green layer):

Put bottle 3, upside down, on top of bottle 2.
Add some gravel to bottle 3.
Add a layer of soil.
Sow the seeds into the soil.
Add a thin layer of soil on top of the grass seeds.
Water the mixture.
Fasten bottle 2 and bottle 3 together using some tape.

EXPLANATION

This experiment shows how to create simulated small ecosystems and connect them all together into a bigger system. This system provides opportunities to understand how energy is brought into the living world and transferred through food chains, and how the living and nonliving environments are connected through cycles of matter. Experiments and data collection can be changed according to the age of the students - the younger ones can just observe the cycles, and the older ones can add data collection to the experiment.

ECO COLUMN

POSSIBLE QUESTIONS

How do the different layers change over time (qualitative and quantitative observations)?
How does the water cycle work?
How does manipulating the different variables change the interactions between the ecosystems?
What can happen if one of the systems is polluted or over-fertilized?
Could you explain a similar relationship in a real ecosystem (Ex. lake, park, biome, …)?

FURTHER INFORMATION

https://www.instructables.com/Eco-Column/
https://sites.google.com/site/butiapes/apes-extended-lab-inc/ecocolumns
https://www.learner.org/series/essential-science-for-teachers-life-science/bottle-biology/bottle-biology-ecocolumn/
https://teachingapscience.com/category/lab/ecocolumns/

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutoral created by the students of the project. Follow this link https://youtu.be/sMpod476fZc or scan the QR code

SOIL HEALTH PARAMETERS

SUBJECT
BIOLOGY
CHEMISTRY
PHYSICS

TOPICS
#EROSION #SOIL BIODIVERSITY #SOIL PH
#FERTILIZERS #SOIL HUMIDITY #SOIL SALINITY

SUBJECT

- Compare different soil types.
- Learn the problems of different areas.
- Learn the importance of healthy soil and how it impacts life quality.
- Learn which plants could grow in this type of soil.
- Assess which soil is ecologically suitable (not contaminated).
- Learn chemistry, biology and physics through IBSE pathways.

LEARNING SCENARIO

Groups: 4 students in one group, one responsible for documenting, two for experimenting and one for clean instruments. The roles can be switched for each test.
Store-bought soil is needed for the control group.
Time needed: 1,5 hours.

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

NPK soil test kit, **3 test tubes**, **2 pipettes**, **distilled water**, **5 cups** for dissolving the soil, **universal indicator**, **multimeter**, **copper** and **zinc plates**, **wires** and **5 boxes** for the soil.

TIPS AND TRICKS

Let the soil water rest so the soil falls to the bottom and the water on top gets clearer.

Place the copper and zinc plates in the soil the same way.

Wash the instruments with distilled water.

The reagents used in NPK tests can be dangerous, be cautious using them.

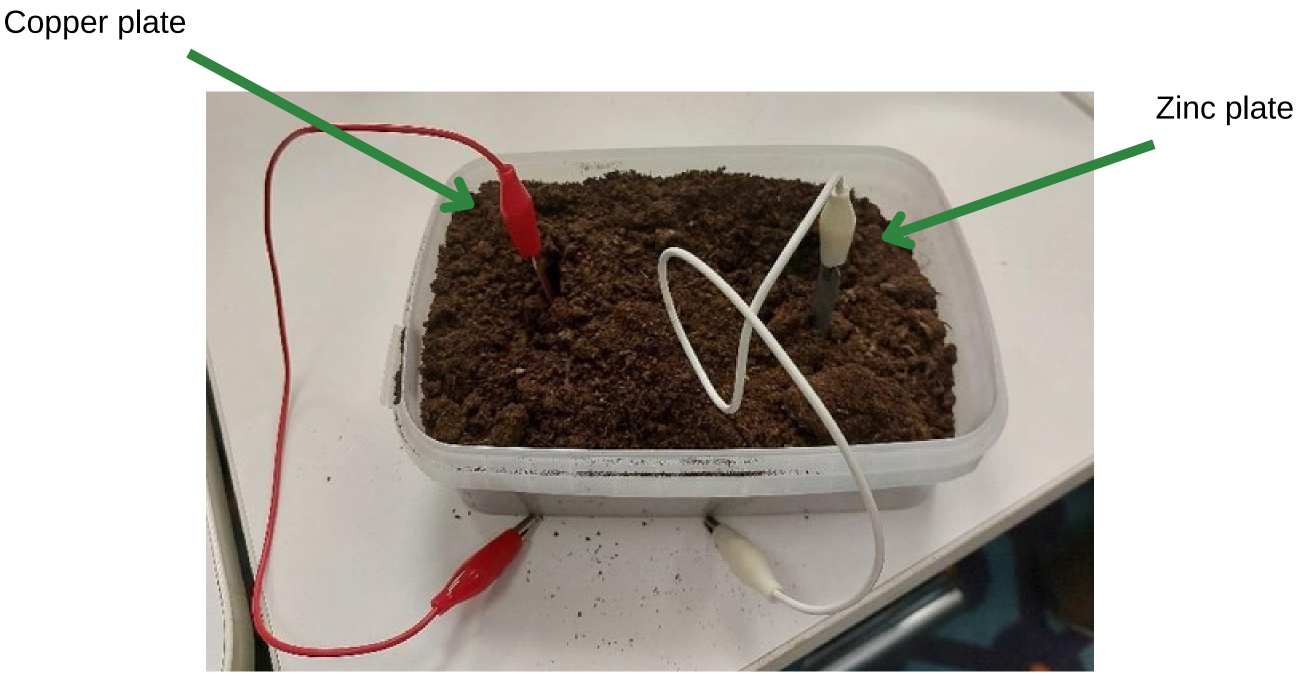
Use rubber gloves, glasses and a mask when experimenting with reagents.

SOIL HEALTH PARAMETERS

TUTORIAL

	Measuring the electrical parameters
STEP 1	Place the zinc and copper plates in the soil as shown in the picture, maintaining the same distance between the plates.
STEP 2	Connect the wires to the plates and another side of the wire to the multimeter. Copper plate to red electrode, zinc plate to black electrode.
STEP 3	Set the multimeter to measure direct current in millivolts.
STEP 4	Document the value of the current.
	Measuring the pH
STEP 5	Dissolve an equal amount of soil in distilled water in small cups. Let the cups rest.
STEP 6	Gather the clear water with a pipette and place it in another cup. Measure the pH with a universal indicator. Compare the color to the indicator scale.
STEP 7	Document the pH value of each soil.
	Measuring NPK
STEP 8	Use the same soil solution for NPK tests. Conduct the tests for each soil as shown in the test kit manual.
STEP 9	Document all the soil parameter values.
	Compare the results and discuss, what could be responsible for such direct current values (soil salinity, pH, high mineral count, area of soil gathering).

SOIL HEALTH PARAMETERS



EXPLANATION

This experiment allows students to compare different soils and their quality. It is recommended to choose different soils from different locations, for example, soil from the side of the road, soil from the home garden, soil from an industrial field, soil from the bog, wetland or forest, store-bought soil. It's important to compare the natural soil to the store-bought soil to see differences in NPK amounts. The nitrogen, potassium and phosphorus amount can be different depending on the seasons.

POSSIBLE QUESTIONS

- Why do we have to assess the quality of the soil?
- Is the soil near the road good for cultivation?
- How are the soil in the home garden and industrial field different in parameters?
- What could you cultivate in each soil?
- What could cause low quality in compared soils?
- Is the air pollution detectable in soil quality?
- Why do we have to let the soil samples rest in the water?

SOIL HEALTH PARAMETERS

FURTHER INFORMATION

https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/co/home/?cid=nrcs144p2_063020#:~:text=Soil%20quality%20is%20how%20well,support%20human%20health%20and%20habitation
https://www.qld.gov.au/environment/land/management/soil/soil-properties/ph-levels#:~:text=Most%20soils%20have%20pH%20values,6.5%20to%207.5%E2%80%94neutral
https://www.sciencedirect.com/topics/earth-and-planetary-sciences/soil-salinity

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutoral created by the students of the project. Follow this link https://youtu.be/DwhBMHxiacA or scan the QR code

THE SECRET OF NATURAL AND SYNTHETIC FRAGRANCES

SUBJECT
CHEMISTRY
BIOLOGY

TOPICS
#ORGANIC CHEMISTRY (ESTERIFICATION, MECHANISM) #SEPARATION TECHNIQUES #CATALYSTS #REVERSIBLE REACTIONS #CHEMICAL METABOLISM #PLANT LIFE AND EVOLUTION.

OBJECTIVES

- To compare the properties of fragrances from chemical synthesis and from natural sources.
- To investigate the use of fragrances and the risks connected with synthetic chemicals.

LEARNING SCENARIO

Groups: at least three groups (one will carry on the chemical synthesis, one will do the distillation and the third the extraction with alcohol. If more groups/ equipment/ chemicals are available, more methods of extraction can be tried and different esters can be synthesized.
Time needed: 2 hours

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

CHEMICAL SYNTHESIS	DISTILLATION OF NATURAL SUBSTANCES	EXTRACTION WITH ALCOHOL
stove **gauze** to cover direct heat **beaker** **orthostatic stand with a clamp** **test tubes** **pipettes** **water** **gloves, glasses** and **lab coat** for safety **paper towels** (just in case) **concentrated sulfuric acid** **different carboxylic acids** (e.g. salicylic acid, palmitic acid, ethanoic acid, propanoic acid) **different alcohols** (e.g. hexanol, ethanol, methanol, butanol)	**stove** **pot** **glass bowl (has to fit in the pot)** **pot lid** **ice cubes** **water** **fruits or flowers** **knife**	**beaker** **ethanol or a spirit with at least 80% ethanol** **fruits or flowers** **knife**

THE SECRET OF NATURAL AND SYNTHETIC FRAGRANCES

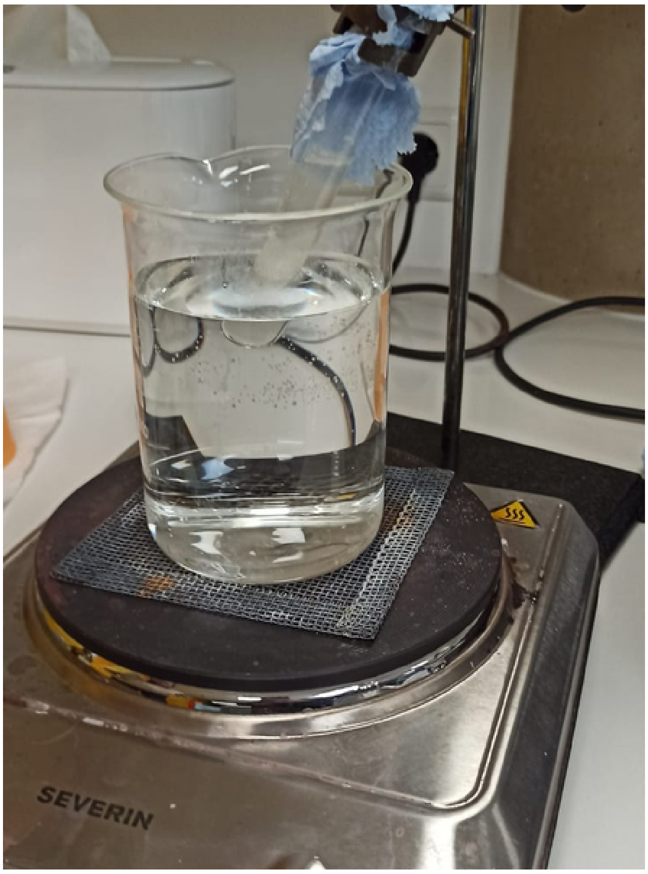
PREPARATION

Some background theory about organic chemistry should be taught in advance so that students understand the reaction. Other related topics (separation techniques, plant evolution, etc.) can be explored in advance or after the experiment (see follow-up questions).

THE SECRET OF NATURAL AND SYNTHETIC FRAGRANCES

TIPS AND TRICKS

Students carrying out the experiment should be at least 15 years old. The experiment can be interesting for younger students but it should be demonstrated by an adult or an older student acting like a tutor.
Only qualified adults can handle the concentrated sulfuric acid.
As for many experiments, it is a good idea to try it in advance to identify the conditions and the chemical combinations that will lead to better results.
Peels could be squashed in a mortar (if available) in order to facilitate the extraction of essential oils.
In the fruit extraction other solvents could be used and their efficiency could be compared. Suitable "home" solvents could be olive oil, sunflower oil, or almond oil.



SAFETY MEASURES:

Research and mind the specific chemical hazards: they will be different for different acids and alcohols.
Treat every chemical as it were dangerous and flammable: avoid touching, consuming, and putting close to a free flame.
Manage hot equipment carefully.
Avoid direct contact between the beakers and the electric stove by using a gauze.
Avoid breaking glass equipment and if it does break, handle it and dispose of it safely.
Use safety glasses, a lab coat and gloves when handling chemicals.
When testing the smell of the synthetic esters, do not inhale directly, rather use your hand or another device to move the air next to the test tube opening.
Handle any sharp tool (e.g. knife) with care.
Dispose of any waste in a way that is environmentally friendly and compliant with EU regulations and local rules.

THE SECRET OF NATURAL AND SYNTHETIC FRAGRANCES

TUTORIAL

	Distillation of natural substances from natural sources
STEP 1	Prepare the samples and cut them into small pieces.
STEP 2	Put a cooking pot on an electric stove and add a small quantity of water, to make the level up to 3 cm approx.
STEP 3	Put the peels in the water and place a glass/mug in the middle of the water.
STEP 4	Put the lid upside down over the pot and when it starts boiling, put some ice cubes on top.
STEP 5	Change the ice cubes when they start melting.
	Synthesis of esters
STEP 6	Put an approximately equal amount of carboxylic acid and alcohol in a test tube (about 1.5-2.0 ml each if they are liquids, about 0.2 - 0.3 g if they are solid).
STEP 7	Add 10 droplets of concentrated sulfuric acid.
STEP 8	Put the test tube in a water bath.
STEP 9	Wait for approximately 15 minutes while mixing a few times in the process.
STEP 10	Add some saturated sodium bicarbonate solution to the mixture until no fizzing is seen.
	Extraction with ethanol
STEP 11	Prepare the fruit/flowers isolating the parts that are richer in essential oils (peels for citrus, petals for rose, etc.)
STEP 12	Cut these materials into smaller pieces.
STEP 13	In a bowl, mix the materials with an adequate amount of solvent.
STEP 14	Let it soak (approximately 48 hours).
STEP 15	Every once in a while mix it.

BOOSTING GREEN EDUCATION

THE SECRET OF NATURAL AND SYNTHETIC FRAGRANCES

EXPLANATION

Esters are usually prepared through a reaction between carboxylic acid and an alcohol, this reaction is known as esterification. Esters are known for their pleasant fragrance and small changes in esters' structure can produce different scents. The reaction between carboxylic acid and alcohol is slow, therefore to speed up the reaction we will heat the mixture and add a catalyst. Sulfuric acid is a good catalyst in this case as an efficient source of H^+. To neutralize sulfuric acid and any remaining carboxylic acid sodium carbonate is used.

Plants produce a huge variety of chemicals because they cannot move as animals do so they perform a number of functions through chemical actions. Examples:

- They use fragrances and colors to attract animals like insects that will allow them to reproduce.
- They produce bitter or poisonous substances to discourage predators.
- They produce chemicals that inhibit the growth of other plants that could compete with them for water, minerals, light, etc.

Different parts of the plant may contain different amounts of certain chemicals. We use the peel of the fruit because it is particularly rich in essential oils (containing esters) but does not have other substances like sugars, water, etc. which would make extraction complicated.

POSSIBLE QUESTIONS

Research the mechanism of ester formation. How do we describe chemical reactions through mechanisms? How do we know that the electrons move that way?

Research some of the metabolic pathways of plants allowing them to produce the chemical that they make. How did plants evolve to produce these chemicals? How does their DNA enable them to produce a distinctive mix of chemicals?

Why do we perceive a single chemical smell in a different way from a mixture of chemicals? Look at materials from the perfume industry.

What are the advantages and disadvantages of synthetic chemicals? Think about both human health and the environment.

What are possible uses for extracted natural chemicals?

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutoral created by the students of the project. Follow this link https://youtu.be/-kctyJ1a_8Y?list=PLOJ89stthyGIwL34eOGyguimPbvXUAk7x or scan the QR code

BEESWAX WRAPPING PAPER

SUBJECT
BIOLOGY

TOPICS
#RECYCLING #ALTERNATIVE MATERIALS #BEESWAX #EXCESSIVE PACKAGING

OBJECTIVES

PURPOSE OF THE ACTIVITY:
- Learn the recycling process
- Learn how to wrap food or leftovers
- Learn about alternative materials and how to use them

LEARNING SCENARIO

Groups: 4 people in a group, in a lab
The time needed: 2 hours - 1 hour to learn the process, 1 hour for the activity
Fun fact: One cloth (40x40cm) costs 15 euros in the shop while self-made beeswax wrapping paper costs 0,36 euros.
Time needed: 2 hours - 1 hour to learn the process and 1 hour for the activity

MATERIALS AND TECHNICAL INSTRUMENTS

Oven, **beeswax**, **brush** or a **spatula**, **gloves**, **pieces of cotton fabric**, **silicone tray**, **oilcloth**, **scissors**

TIPS AND TRICKS

Don’t put too much beeswax between the fabric.
Be careful with the heat, heat should be around 100-150 degrees, higher heat burns the wax.
If you want to clean the wax paper, use some water and a washing cloth.
You can remove excessive wax by using a fork or a knife.
You can reuse the wrapping paper if some spots are worn out by melting more beeswax on the cloth.
You can spread out the beeswax using a brush or a spatula.
Lay the wet cloth correctly to avoid wrinkles.

BEESWAX WRAPPING PAPER

BEESWAX WRAPPING PAPER

TUTORIAL, PROTOCOL

STEP 1	preheat the oven to 125 degrees Celsius
STEP 2	cut the cloth to size, depending on the measurements of the silicone tray
STEP 3	fold the cloth twice and place it on the tray
STEP 4	sprinkle enough beeswax pieces between every layer
STEP 5	put the tray into the oven and let the wax melt for about 5 minutes
STEP 6	make sure that all of the wax is melted from solid to liquid
STEP 7	to be sure, take the cloth out and spread the wax with a brush, and put it back in the oven for 1-2 minutes
STEP 8	open the oven, take out the cloth, and lay it fast but correctly on the oilcloth
STEP 9	let the cloth rest for 5 minutes and your wrapping paper is ready to use

EXPLANATION

The experiment shows how to use natural waterproof materials to avoid other harmful materials. We are not only replacing harmful materials with natural ones but also reusing cotton and giving a piece of cloth a new life.

Honey bee workers have four pairs of special wax-secreting glands on the undersides of their abdomens. From these glands, they secrete liquified wax, which hardens into thin scales when exposed to the air. As the worker bee ages, these glands atrophy, and the task of making wax is left to younger bees.

BEESWAX WRAPPING PAPER

POSSIBLE QUESTIONS

How long can you use the wrapping paper?
How much does it cost?
Could we use another material aside from cotton?
What kind of food is it made for?
How many kilos of waste can you avoid by using beeswax wrapping paper?
Does it burn?
What is the maximum temperature we can cover with wrapping paper?
Are there any options to change the smell of the paper?
Is it moral to take away the beeswax?

FURTHER INFORMATION

https://www.youtube.com/watch?v=eyZ1T0_t7bk
https://www.purewow.com/home/uses-for-beeswax
https://supplychain.edf.org/resources/sustainability-101-packaging-waste-the-problem/
https://www.forbes.com/sites/jonbird1/2018/07/29/what-a-waste-online-retails-big-packaging-problem/?sh=6b9df6c0371d
https://www.lesswaste.org.uk/reduce/think-packaging/
https://www.youtube.com/watch?v=nZlEjDLJCmg
https://www.youtube.com/watch?v=f6mJ7e5Ymn

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutoral created by the students of the project. Follow this link https://youtu.be/-nKd-GZBFa8 or scan the QR code

ACID RAIN

SUBJECT
ENVIRONMENTAL SCIENCE

TOPICS
#ACID RAIN
#ENVIRONMENTAL EFFECTS

OBJECTIVES

- Raising awareness about the effect of acid rain on soil acidity
- Learning about the decontamination and soil recovery measures used in cases of acid rain impact
- Raising awareness of the effect of acid rain on marble statues

LEARNING SCENARIO

Groups: 3-4 students per group, each group needs three beakers and three soil samples.

Time needed: 30 minutes to explain the procedure and 60 minutes to do the experiments.

MATERIALS AND INSTRUMENTS TO MAKE THE 4 EXPERIMENTS

Three **beakers**
Three **soil samples**
Water
Filter paper
pH paper
Lemon
Calcium carbonate
Chalk powder
Lime
Two **pieces of marble**

PREPARATION

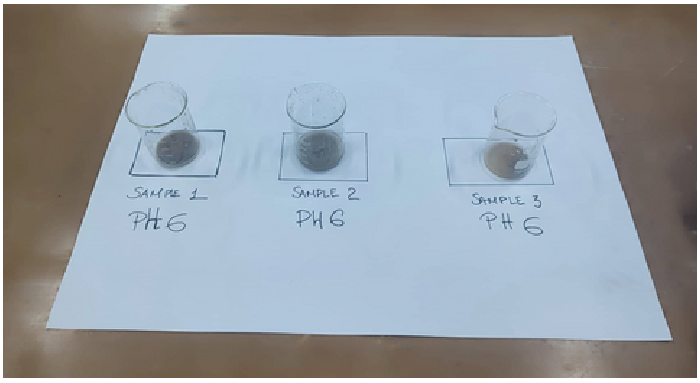
Acid rain is formed by the combination of moisture in the air with SO2, SO3 and N2 oxides, which are found in pollutants such as petroleum products, waste and fumes from factories and vehicles, etc.
In our experiments we first measured the pH of the soil from the flower garden of our school. We then increased its acidity with lemon to simulate the effect of acid rain. Then we tried to reduce the acidity and increase the basicity of the soil by mixing it with calcium carbonate, chalk dust and lime water.
Finally, we observed the effect of acid rain on marble statues.

ACID RAIN

TUTORIAL

EXPERIMENT 1: SOIL PH MEASUREMENT

We took three soil samples from our school's flower garden.
We mixed them with an equal volume of water and stirred them well.
We filtered the samples and measured the pH of the filtrates with pH paper.
The pH of the three samples was estimated at 6.

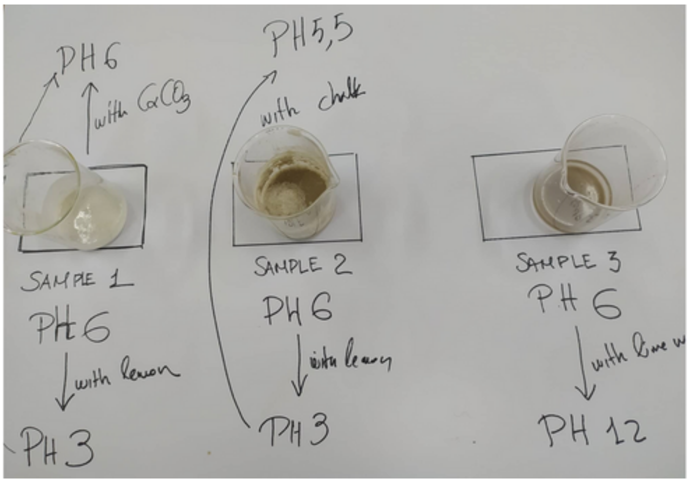


EXPERIMENT 2: INCREASING SOIL ACIDITY

We mixed the first two samples with lemon juice.
We followed the steps of the 1st experiment and measured the pH of the samples ground.
The pH of the two samples was estimated at 3.

EXPERIMENT 3: REDUCTION OF SOIL ACIDITY

We mixed the first sample with calcium carbonate and measured the pH=6.
We mixed the second sample with chalk powder and measured the pH=6.
We mixed the third sample with lime water and measured the pH=12.

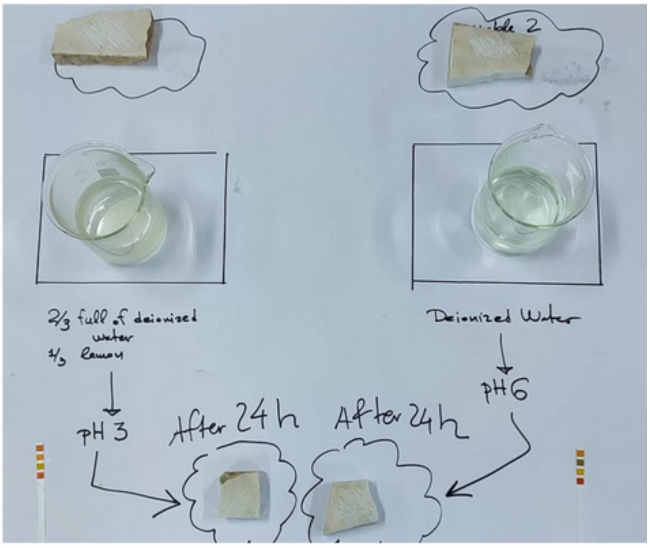


ACID RAIN

TUTORIAL

EXPERIMENT 4: EFFECT OF ACID RAIN ON MARBLE STATUES

We measure the pH of the deionized water.
Make a solution with a pH of about 3 by adding 3 spoons of lemon juice to a cup 2/3 full of deionized water.
Make a shape with something sharp on a piece of marble and put it in a glass filled with the acid solution.
Make the same shape on a second piece of marble and put it in another glass filled with deionized water.
Leave the glasses for 24 hours and observe.



EXPLANATION

Acid rain as a solution of acids increases the acidity of soils with dramatic effects most of the time.

Mixing the soil with lime and other basic solutions, due to the neutralization reaction, reduces the acidity of the soil. That is why in some cases of pollution with acid rain, the addition of limestone or lime dust has been applied to deal with the problem.

BOOSTING GREEN EDUCATION

ACID RAIN

POSSIBLE QUESTIONS

- What other solutions can we use?
- How does acid rain effect surface water (lakes, rivers, seas)?
- What is the consequence of it?

FURTHER INFORMATION

https://en.wikipedia.org/wiki/Acid_rain
https://www.youtube.com/watch?v=1PDjVDIrFec&ab_channel=NationalGeographic
https://www.youtube.com/watch?v=dmgLESI4GGU&ab_channel=KINETICSCHOOL
https://www.youtube.com/watch?v=Nf8cuvl62Vc&ab_channel=FuseSchool-GlobalEducation

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutorial created by the students of the project. Follow this link https://youtu.be/9vTebnXxeNo or scan the QR code.

ENERGY SAVING WITH AUTOMATIC LIGHT CONTROL

SUBJECT
PHYSICS
MATH
PROGRAMMING

TOPICS
#GREEN EDUCATION
#ENERGY SAVING
#ARDUINO PROJECT

OBJECTIVES

Electricity consumption is increasing every year because of the demand of users. Commonly electricity use is in lighting systems, audio systems, daily routines and other things. Most usage of the electricity consumption is lighting systems because with light people can do a job or task easily when at day night or in a dark area. Therefore, the objective of this scientific sheet is the development of energy saving smart light system.

LEARNING SCENARIO

Groups: 2-3 students per group, suitable for high school students.

Time needed: 2 hours.

MATERIALS AND INSTRUMENTS TO MAKE THE EXPERIMENT

Login to **TinkerCad** with class code (provided by the teacher): www.tinkercad.com
1 **Arduino Uno**
1 **Ultrasonic Sensor HC-SR04**
1 **Breadboard**
1 **LED**
1 **Resistance 220Ω**

PREVIOUS PREPARATION

The lesson is planned to take place in the Computer Lab. A computer with internet access is used (for simulation in Tinkercad) as well as a video projector to present the information. Students are able to transfer files from their computers to the account folders created by the teacher and vice versa. The students are divided into groups of 3-4 people (depending on the number of students in each class).

ENERGY SAVING WITH AUTOMATIC LIGHT CONTROL

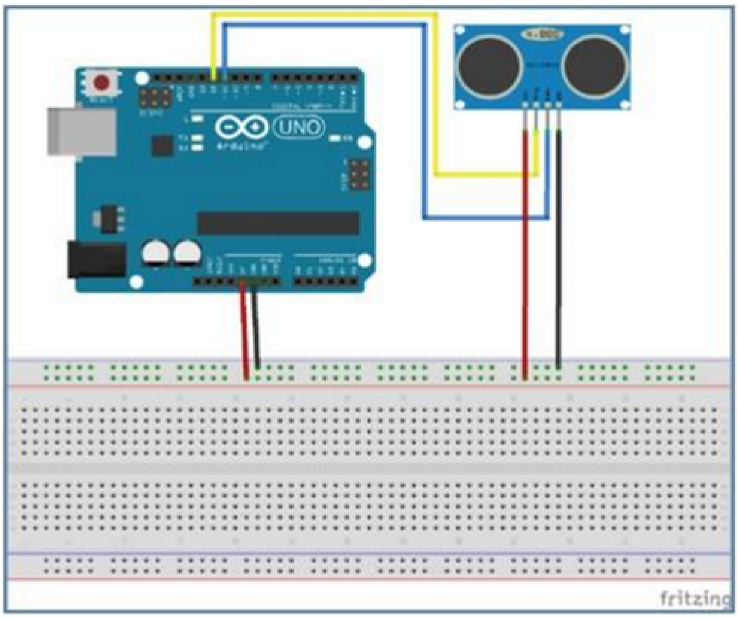
TUTORIAL

DISTANCE MEASUREMENT

We will first connect an Ultrasonic sensor to an Arduino Uno to measure the distance to an object. An ultrasonic sensor is an electronic device that measures the distance of a target object in a range of 2-400 cm, emitting ultrasonic waves, converting the reflected sound into an electrical signal. Ultrasound sensors consist of two (2) parts. The transmitter-trigger (which emits sound using piezoelectric crystals) and the receiver-echo (which receives the sound after traveling to and from the target). To calculate the distance between the sensor and the object, the sensor measures the time required between the sound transmission from the transmitter to the impact surface and its return to the receiver. The formula for this calculation is $D = ½ T x C$ (where D is the distance, T is the time and C is the speed of sound ~ 343 meters/second). These values will be displayed on the serial display.

CIRCUIT LAYOUT

Connect the materials gathered using the wiring diagram below.

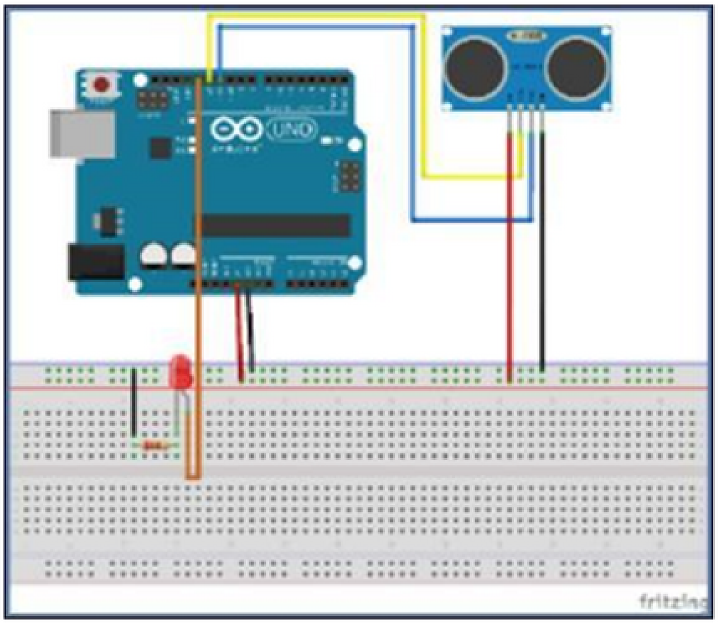


Program the image circuit so that the ultrasonic sensor measures the distance in centimeters every 0.25 sec. The sensor values are displayed on the Arduino serial display.

ENERGY SAVING WITH AUTOMATIC LIGHT CONTROL

TUTORIAL CONTINUATION

We will enrich the circuit of the previous section, so that an LED lights up when an object approaches the sensor.



Modify the program of the module so that the LED lights up when it approaches an object in front of the ultrasonic sensor at a distance of less than 20cm.

EXPLANATION

Through the experiment of this worksheet, the students will identify how they can save energy around their homes. They will understand how much electricity they use every day and why is important to save energy in order to protect the environment. They will discuss the steps they can take to conserve energy by reducing wasteful energy uses.

Also, through the Arduino environment, students will understand the operation of simple electronic circuits and components, and how their operation can be controlled via the microcontroller.

ENERGY SAVING WITH AUTOMATIC LIGHT CONTROL

FURTHER INFORMATION

www.tinkercad.com: a free, easy-to-use web application for 3D design, electronics and coding.

https://www.youtube.com/watch?v=9XRx2cE8HDo&ab_channel=MakerTutor

https://www.youtube.com/watch?v=I5-gq7J7lM4&ab_channel=MERTArduino%26Tech

https://www.youtube.com/watch?v=ndBPXeav2rI&t=622s&ab_channel=ciastudies

https://www.youtube.com/watch?v=fJWR7dBuc18&ab_channel=PaulMcWhorter

https://www.tinkercad.com/things/1XyuMz7pjng

https://www.youtube.com/watch?v=9XRx2cE8HDo

https://www.tinkercad.com/things/9QsHOvKqxXY

https://www.youtube.com/watch?v=I5-gq7J7lM4

https://www.tinkercad.com/things/8XjmlgaWC6c

https://www.youtube.com/watch?v=lLk1T6JrRjQ&ab_channel=RoboticaDIY

https://www.youtube.com/watch?v=s03Pa5ez3hA&ab_channel=FairElectro

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutorial created by the students of the project. Follow this link https://youtu.be/1X2q4HonX-M or scan the QR code.

NATURAL DISASTERS PROTECTION

SUBJECT
PHYSICS
ENVIRONMENTAL SCIENCE

TOPICS
#SOIL MOISTURE #WATER MANAGEMENT #CLIMATE CHANGE #AUTOMATION SYSTEMS #STEM #MICRO:BIT

OBJECTIVES

- Learn about climate change dangers
- Learn about water management methods and systems
- Learn how to use sensors to conduct measurements
- Learn how to program Micro:bit to create a notification system

LEARNING SCENARIO

Groups: 2 students per group, or according to the devices available (computers and Micro:bits).
Age of students: 12+ (upper primary or secondary education level).

Time needed: 1 hour to teach Micro:bit and 1 hour for the activity.

MATERIALS AND INSTRUMENTS (FOR EACH GROUP)

1 **Micro:bit** with battery pack and batteries (USB cable included); **computer**; 6 **long nails**; 2 **crocodile clips**; **cardboard**; **soil container** and **soil** (x3); **water**; **pen and paper**.

TIPS AND TRICKS

Students will first get familiar with Micro:bit as a device, its' connectivity options and its' programming environment. They will try to create a simple program, load it to the Micro:bit and test it. Then they will navigate to the programming environment and try to investigate the various options it provides for taking measurements and providing special messages and sounds. They will discuss the connectivity of the device and try to propose cases where Micro:bit could be used as an alarm system to prevent from natural disasters (e.g. desertification or floods).
The teacher will guide students through the process to use Micro:bit and create a simple program for the measurement of the soil moisture and the creation of appropriate messages according to the level of moisture. Students will then be encouraged to use their fantasy and creativity to propose other possible alarm systems, given the features of Micro:bit available.

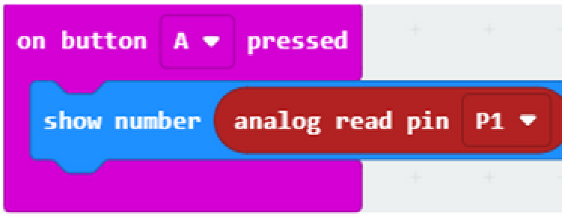
NATURAL DISASTERS PROTECTION

BOOSTING GREEN EDUCATION

PREVIOUS PREPARATION

Arrange the classroom in groups of students and workstations (computers).
Collect some dry soil from the yard or wherever available and put the same amount of soil into each of the three containers.
Hand out a Micro:bit controller to each team.
Visit https://makecode.microbit.org/ and navigate through the lesson plans provided by the site. Get familiar with the Micro:bit by watching the videos and experimenting with the device. Try to create a simple program and test it on Micro:bit.

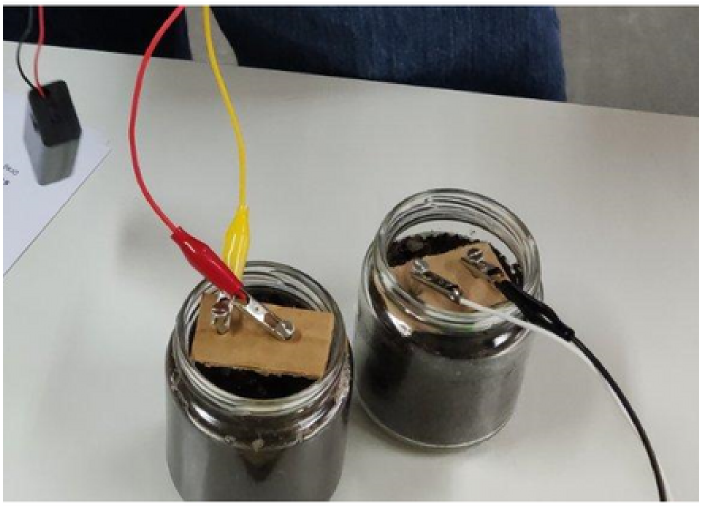
TUTORIAL

STEP 1	Cut the cardboard in 3 equal pieces and punch each piece with 2 nails.
STEP 2	Insert the nails into the soil, 2 nails in each container.
STEP 3	Add some water to the 2 of the containers, so that the one gets moisturized and the other gets wet. Label each container accordingly.
STEP 4	Visit https://makecode.microbit.org/, create a new project and name it. Drag and drop blocks from the left panel to create the following code: 
STEP 5	Download the code, drag and drop it into your Micro:bit.
STEP 6	Connect one nail to the 3V pin and the other to the P1 pin of your Micro:bit, using the crocodile clips.
STEP 7	Press the A button and write down the measurement of the Dry container (e. g. around 700).
STEP 8	Connect your crocodile clips to the second containers' nails, press the A button again and write down the measurement as Moist (e. g. around 900).
STEP 9	Connect your crocodile clips to the third containers' nails, press the A button again and write down the measurement as Wet (e. g. around 1010).

NATURAL DISASTERS PROTECTION

TUTORIAL CONTINUATION

STEP 10	Now you know the values of the three conditions of the soil and you can program Micro:bit according to them.
STEP 11	Go back to your editor, drag, and drop blocks from the left panel to create the following code: 
STEP 12	Adjust the values of the conditions (moisture>_?_) used above to the ones you have written down while doing your measurement.
STEP 13	Try to add some Tones (from the Music block) to the proper block, so that the system notifies you when the soil is too dry.
STEP 14	Download the new code, drag and drop it into your Micro:bit.
STEP 15	Connect the crocodile clips to the Dry container. What will happen?



NATURAL DISASTERS PROTECTION

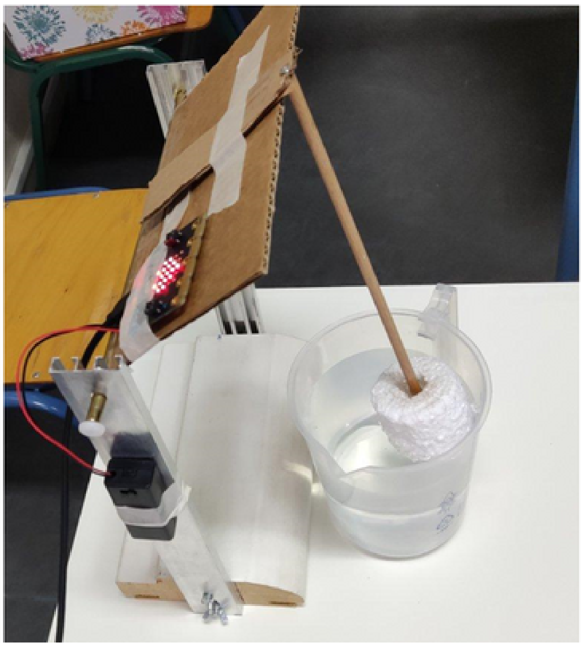
EXPLANATION

Micro:bit senses the soil's moisture through the nails, which act like sensors. Dry soil is not a good conductor of electricity, but as the soil gets wet it becomes a better conductor of electricity. So, electricity flows between the nails and the value is recorded by the Micro:bit through the pins. If the moisture is over 1010 (the value may differ, depending on the soil and the measurements), then the first block of commands is executed (show an icon, or play a sound, or both), if the moisture is between 900 and 1010 the second group of commands is executed, otherwise the third group of commands is executed.

Through this experiment students get introduced to programming and connecting devices like Micro:bit to conduct measurements and manage systems and situations. Teachers and students will discuss other cases where Micro:bit could be exploited to create systems to prevent from natural disasters. The case of a flood could be used as an example, since Micro:bit could be used and programmed to measure the water level and broadcast corresponding signals. Teacher could feed a relevant discussion by asking questions regarding the types and causes of natural disasters and what should people do to protect from them. Moving on to the technical part of the discussion, teachers and students could investigate the various commands and sensors of the Micro:bit and try to propose systems (constructions and programming) to protect people from possible natural disasters.

POSSIBLE QUESTIONS

- Can you name some natural disasters that threaten humanity? Which natural elements cause such disasters?
- Can we measure the strength/level/value of a natural element using Micro:bit? How?
- Can you think of/propose a way to exploit Micro:bit, to protect from a natural disaster?
- Which other cases can you use Micro:bit in?
- Design and program a notification system to protect you from a flood, using Micro:bit (see image on the side).
- Can you try to extend your project and create an automatic watering system using Micro:bit?



FURTHER INFORMATION

https://en.wikipedia.org/wiki/Soil_moisture
https://en.wikipedia.org/wiki/Desertification
https://www.nationalgeographic.com/environment/article/desertification
How to measure wind & water with Micro:bits:
https://www.youtube.com/watch?v=l7Jw-Eps_Hs
Micro:bit plant water pump:
https://www.youtube.com/watch?v=jANCdtkJAKY
Micro:bit Automatic Plant Watering System:
https://www.youtube.com/watch?v=rv4lb-U9QUU

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutorial created by the students of the project. Follow this link https://youtu.be/0D4GKf79oHE or scan the QR code.

NOISE POLLUTION

SUBJECT
PHYSICS
MATH
ENVIRONMENTAL SCIENCE

TOPICS
#NOISE POLLUTION #CITY/URBAN PLANNING #SOUNDPROOFING #NOISE CANCELLATION

OBJECTIVES

- Prove the relation between sound amplitude and distance from the source.
- Compare the muffling effect between objects of dissimilar materials.
- Provide everyday examples of noise pollution in the typical urban environment.
- Estimate the psychosomatic effects of common sounds and noises, at different volume levels.

LEARNING SCENARIO

Groups: 3-6 students per group.
Suitable for high school students.

Time needed: 30-45 minutes.

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

Smartphones or **other web-enabled devices** such as tablets or laptops
Internet connection
Speaker (optional)
Measuring tape
Cardboard
Foam insulation material
A pair of **foam or silicone earplugs** for each student

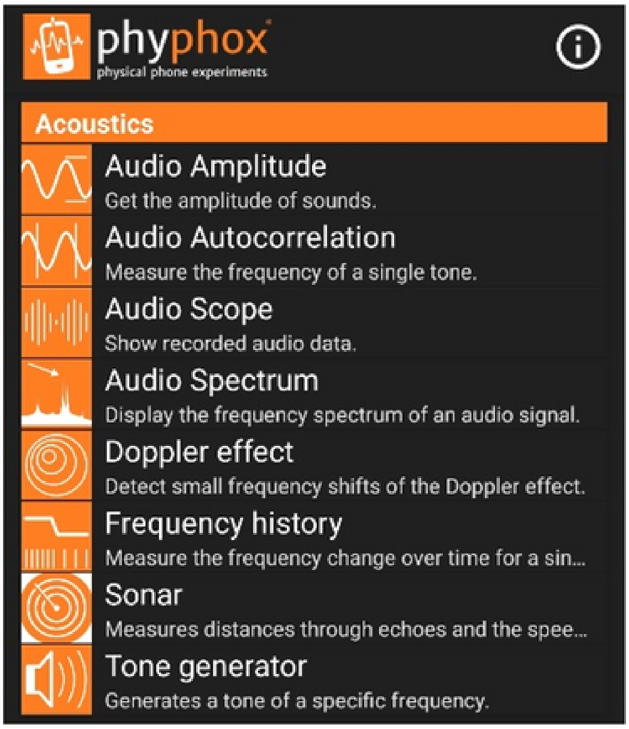
PREVIOUS PREPARATION

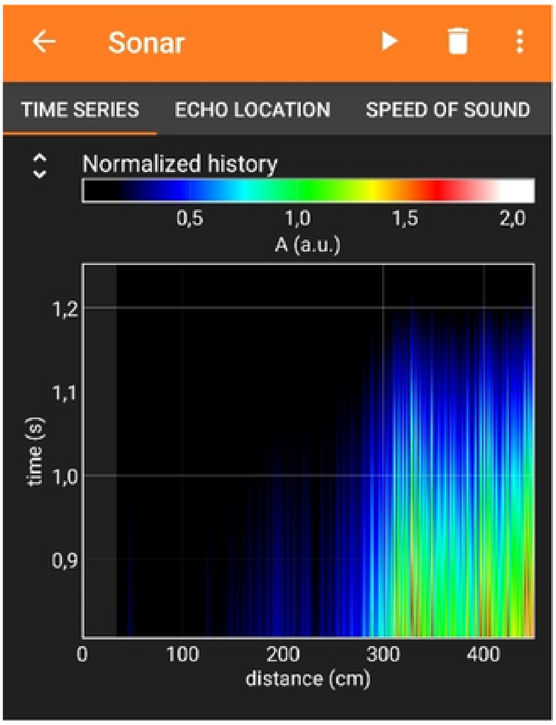
Arrange the classroom in separate groups.
Hand out the materials needed for each team, as mentioned above, along with the worksheet.

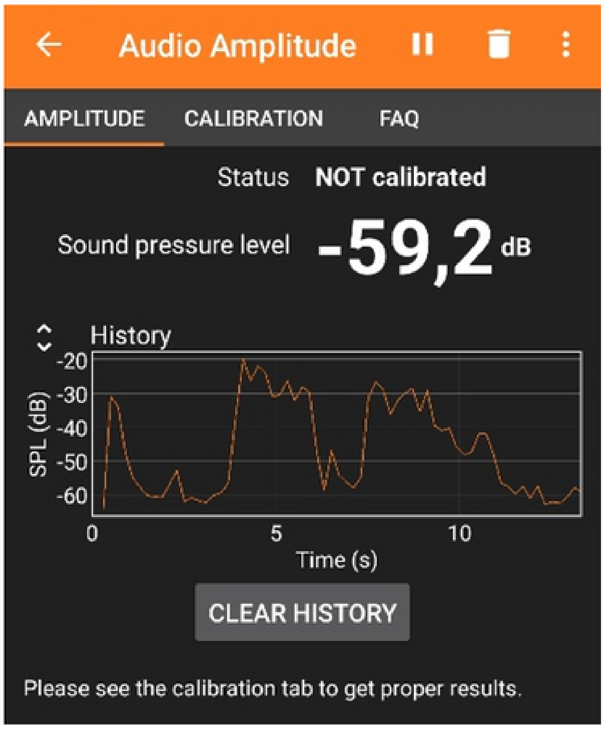
NOISE POLLUTION

TIPS AND TRICKS

For the first part of the activity, the students will pair up two desks at their short side, to make a long horizontal stretch to serve as a workbench for each group, consisting of 3-6 persons. For the second and final part, the participants will sit in a circle, with a desk or chair placed in the center. The students will conduct the experiment themselves, under the supervision of the professor. They will take all the necessary measurements, evaluate the collected data, and draw conclusions using the scientific method of deduction.







NOISE POLLUTION

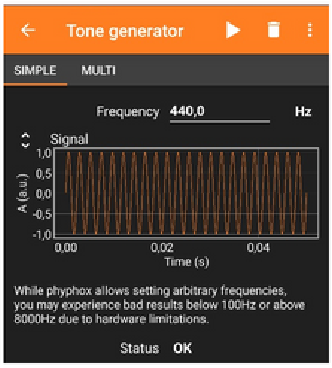
TUTORIAL

STEP 1

Connect one smartphone to the speaker.

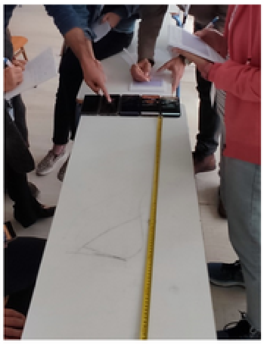
STEP 2

Open the app "phyphox" and play a sound of a specific frequency, using the tone generator function.



STEP 3

Using the same app on another device, measure the sound amplitude at 0.1, 0.2, 0.5, 1, 2, 5 meters from the speaker.



STEP 4

For each measurement use 3 - 6 different phones in order to calculate the average and compare the calculated values.

STEP 5

Then place the phones used for measuring the volume at 0.5 meters away from the speaker.

STEP 6

At the half-point between them, place a piece of cardboard. Record the change in amplitude, if any.

STEP 7

Repeat step 4.

NOISE POLLUTION

TUTORIAL CONTINUATION	
STEP 8	Repeat step 6 using another material.
STEP 9	Repeat step 4.
STEP 10	Retake the same measurement for 2, 4, 6, and 8 pieces of cardboard joined together and repeat step 4.
STEP 11	Replace the cardboard with the piece of insulation foam retake measurements and repeat step 4.
STEP 12	Observe the amplitude change.
STEP 13	Disconnect the first phone from the speaker.
STEP 14	Have all the members of the group sit in a circular arrangement, each holding their phone with the volume set to maximum.
STEP 15	Place the device used for measuring the sound amplitude in the center of the circle.
STEP 16	Gradually have each participant play a sound from the natural or urban environment. Continue until each student will play a sound at the same time.
STEP 17	Record the change in total sound amplitude at each step, as well as the emotional response of the group.
STEP 18	Have each student wear a pair of earplugs.
STEP 19	Repeat step 12, this time only writing down the mood of each participant, not the amplitude measured.
STEP 20	Plot the gathered data and extrapolate them.

NOISE POLLUTION

EXPLANATION

The experiment consists of two parts. The former part aims to familiarize the students with the necessary equipment, as well as show the relation between sound amplitude and distance from the noise source and the effects of different soundproofing materials.
The latter has the purpose of identifying the short-term psychosomatic effects noise pollution may cause on a person. It can show the correlation between the total sound amplitude of the noise and the distress the listener feels. Furthermore, it is bound to discern the severity of this effect when it originates from natural or synthetic noises.
Noise pollution is a phenomenon that originally became noticeable during the Industrial Revolution and became increasingly relevant to our everyday lives after the proliferation of the automobile, at the beginning of the 20th century. Nevertheless, its physical and psychological effects have been studied only recently, during the past two decades. As a result, it should be stressed that relevant information is limited, and relevant facts could be difficult to establish with any degree of certainty.

The purpose of this experiment is to familiarize the students with the basic concept of noise pollution, the fundamental properties of sound, and sound-proofing techniques which could potentially be used to combat the environmental problem at hand. Furthermore, the participants are called to experience a simulation of noise pollution and describe their physiological and psychological reactions to it. In this manner, the importance of combating this ever-increasing phenomenon as part of achieving "green" sustainability, especially -but not limited- in urban environments becomes profoundly clear.
The conduction of the experiment requires little equipment and as a result, is easily reproduced in any classroom environment. In the last few years, smartphones (or other devices) with a stable internet connection and sound-producing ability have become commonplace amongst kids and adults alike. In addition, it is suitable for a wide range of ages and there is a substantial elasticity to the participants' group size and the tutor's preferred method of teaching.

POSSIBLE QUESTIONS

- What are some instances of noise pollution you've personally experienced?
- What do you think is noise pollution? Can you give any examples?
- Where do you believe noise pollution is more pronounced?
- What could we do to combat it?

NOISE POLLUTION

FURTHER INFORMATION

Using their own smartphones or other web-enabled devices (such as tablets and laptops), the students search online for recordings of sounds and noises that can be observed in a typical forest, suburb, city center. It is critical that there are examples of sounds of each of these three categories.
A couple of short, educational videos regarding the topic of noise pollution will be shown to the students. These not only serve as informative sources but moreover as attention-grabbing media which impress the viewer and instill in them the will to learn more about the topic at hand.

"Musical Fire Table!"
https://www.youtube.com/watch?v=2awbKQ2DLRE
"How noise pollution is ruining your hearing"
https://www.youtube.com/watch?v=z4Da0kuYnMI
"Is city noise making us sick?"
https://www.youtube.com/watch?v=qryWWGP0kKs
A few interesting and fun online applications may also be used, such as:
"Chrome Music Lab"
https://musiclab.chromeexperiments.com/
"Blob Opera"
https://artsandculture.google.com/experiment/blob-opera/

FOLLOW-UP EXPERIMENTS AS HOMEWORK

- Record noise levels of ambient sound at different times and places and discuss their effects.
- Different places of the school at different times.

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutorial created by the students of the project. Follow this link https://youtu.be/XFV-pBBm9Uc or scan the QR code.

BOOSTING GREEN EDUCATION

ZERO WASTE SOCIETY

SUBJECT
PHYSICS
MOLECULAR SCIENCE
CHEMISTRY
ENVIRONMENTAL AND EARTH SYSTEM

TOPICS
#RECYCLING #SUSTAINABILITY
#ENVIRONMENT #ZERO WASTE SOCIETIES
#MATERIAL SCIENCE

OBJECTIVES

- Understand the meaning and importance of sustainability
- Realize how sustainability relates to environment, economy, and equity
- Comprehend the 6R – the 6 basic principles of sustainability
- Explore how reuse reduce recycle leads to Zero Waste Societies
- Embrace the above principles and change their consuming behaviour in order to be part of Zero Waste Societies

LEARNING SCENARIO

Groups: 3-4 per group.
Time needed: 40 minutes.

Styrofoam is all around us. It has become one of the most common insulators and packaging materials in the world. Styrofoam coffee cups keep our drinks warm, packing peanuts keep our valuables safe in shipping, and it even keeps our drinks nice and cool inside our cooler on a hot day. It usually ends up in landfills because there are no recycle bins for Styrofoam.

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

Acetone
Styrofoam
Safety Glasses and **gloves**
Container to hold acetone/polystyrene mixture (fiberglass or glass).

PREVIOUS PREPARATION

Open the windows.
Locate on a table the large bowl and the acetone.
Wear safety glasses and gloves.

TIPS AND TRICKS AND SAFETY

DO NOT dispose down the drains, as main pipeline ingredient used is PVC and sensitive to acetone.
Styrofoam – It takes up much less volume, therefore disposal can be of a diminished landfill footprint.
If disposal is an option, make sure to follow the proper chemical disposal procedures.




TUTORIAL

STEP 1

To carry out an experiment with Styrofoam and acetone, all you need is a large bowl or measuring glass. Pour the acetone into the container, then slowly add pieces of Styrofoam. You can use a large piece of Styrofoam, Styrofoam beads or even a Styrofoam cup. Another way of doing this is to pour acetone directly onto a piece of Styrofoam.

STEP 2

Do the experiment in a fume hood or well-ventilated room, and wear safety glasses and gloves. Styrofoam dissolves in acetone in a similar way to how sugar dissolves in water. It is a physical rather than a chemical reaction. The air in the foam leaves, and because Styrofoam consists mainly of air, when it dissolves in acetone it completely loses its structure. The acetone splits up the long chain of molecules, and the air disappears, causing the volume to shrink radically.

STEP 3

The Styrofoam does not completely disappear, even though it looks like it has. Rather, the polystyrene molecules are actually present in the acetone solution. The reaction between Styrofoam and acetone shows how soluble the plastic is in an organic solvent and how much air is in Styrofoam.

STEP 4

At the end of the experiment, you get a number of materials to be disposed:
Used Acetone – Poor acetone to another container (not plastic!) and store it for future use (experiments of application as a solvent).

ZERO WASTE SOCIETY

EXPLANATION

Styrofoam is the trademarked name of the plastic foam polystyrene. Polystyrene is not biodegradable and resists compression, making it a persistent part of landfill waste. When acetone and polystyrene are combined, the polystyrene dissolves. For the investigatory project, the student could explore the effectiveness of acetone in reducing polystyrene for recycling. The student could measure how much polystyrene is dissolved by a particular volume of acetone

Styrofoam dissolves in acetone, it doesn't actually melt - melting requires heat. So, the correct question is: Why does acetone dissolve styrofoam?
Polystyrene is made up of many smaller molecules called monostyrene. The acetone (formula (CH3)2CO) breaks the bonds that hold the polystyrene together. And, because styrofoam is mostly pockets of air, when the bonds are broken the air can escape. As the air escapes the volume of the styrofoam decreases. The foam doesn't disappear, it turns into a liquid, mostly void of the air that made it so valuable as an insulator.

Deep Thinking

Melting a sugar cube is a physical change because the substance is still sugar. Burning a sugar cube is a chemical change.

Is melting styrofoam a chemical or physical reaction?

POSSIBLE QUESTIONS

- Do your results suggest that the volume of acetone indicates how quickly the Styrofoam dissolves?
- Does the volume of acetone affect how much polystyrene can be dissolved in a single beaker?
- Does dissolving polystyrene in acetone add to the weight of the beaker, and does it match the weight expected by the number of Styrofoam cups added to the beaker?
- Would the application of acetone or another solvent to an existing landfill dissolve any polystyrene present beneath other garbage?
- How much solvent would it take to penetrate 1 foot of garbage?
- Does the residue of dissolved polystyrene affect the biodegradability of the surrounding matter?
- What other uses of Styrofoam can be suggested?

FURTHER INFORMATION

https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials
https://www.youtube.com/watch?v=zx04Kl8y4dE&ab_channel=UCLA
https://sustainability-success.com/6-rs-of-sustainability-lifestyle-9-3-rs/
https://prezi.com/f4kwsqvvclyw/chemical-reactions-styrofoam-and-acetone/?frame=6fd3d740ce3353cfe6140aa4e58102c64c81657f

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutorial created by the students of the project. Follow this link https://youtu.be/OC4DxsYU2fA or scan the QR code.

FLOATING ROCKS AND RIVERS IN THE OCEAN: ICEBERGS AND OCEAN THERMOHALINE CIRCULATION

SUBJECT

ENVIRONMENTAL SCIENCE

TOPICS

#CLIMATE CHANGE #SEA LEVEL RISE #OCEANIC THERMOHALINE CIRCULATION #ICEBERG #ELNIÑO

OBJECTIVES

- Know the principles of the oceanic thermohaline circulation and basic principles of climatic phenomena such as El Niño
- Raising awareness about climate change and the effects of rising sea levels in the polar areas
- Know what an iceberg is and how we can study it

LEARNING SCENARIO

Groups: 5 to 15 students.

Time needed: 50 to 60 minutes.

Location: Classroom or Laboratory.

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

Water and **ice** with pastry colors (red for hot water, blue for cold and black for ice); **Salt**; **Duck tape**; A **square fish tank**; Two **plastic glasses**; A **hand fan**; A **bucket** with a **block of ice**; A **concave plastic container**; **Stirrer stick**.

PREPARATION

This activity allows us to observe how the rise in sea level affects the masses of ice found in polar latitudes, how the different masses of water do not mix because they have different densities, how ice floats and how meltwater melts. For this, a bucket with a block of ice is used to simulate the polar caps. The bucket is placed in the fish tank and filled with hot water (tinted with red color) until the ice ends up separating from the bucket. Next, cold and salt water (tinted blue) is added and carefully poured into the tank which is already filled with fresh and warm water (tinted red). The blue water passes through the red water and fills the deepest layer of the tank with hardly any mixing with the surface red water. Next, a block of ice with small stones (tinted black) is added and it is observed how it floats and where the stones and the water from its melting end up. Finally, a small fan is used to see how the wind affects the iceberg and the bodies of water in the tank.

FLOATING ROCKS AND RIVERS IN THE OCEAN: ICEBERGS AND OCEAN THERMOHALINE CIRCULATION

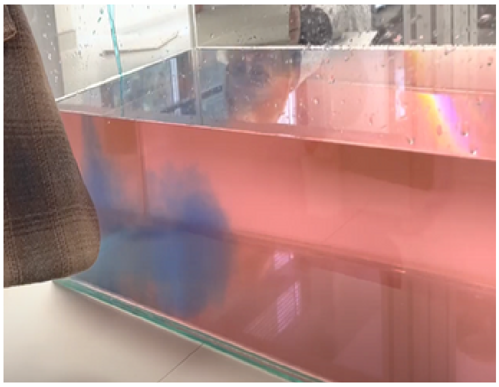
TIPS AND TRICKS

- Fill with hot water (tinted red) until the ice separates from the bucket.
- Carefully add cold and salt water (tinted blue) into the tank that is already filled with fresh and warm water (tinted red). The blue water passes through the red water and refills the deepest layer of the tank with little mixing with the surface red water.
- Add a block of ice (tinted green) and observe how it floats and where the water from its melting go.

TUTORIAL

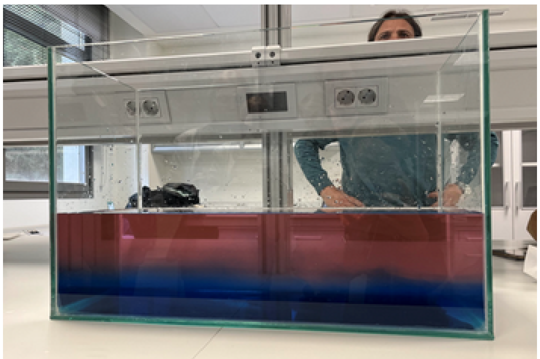
EXPERIMENT 1: RISING SEA LEVEL IN ANTARCTICA

Put a block of ice in the fish tank to simulate the Antarctic polar cap.
Fill with hot water (tinted red) until the ice separates from the bucket.
Evidence the presence of a tipping point. When the hot water enters the cavity below the ice, the ice will melt together.



EXPERIMENT 2A: THERMOHALINE CIRCULATION

Fill the fish tank of red, hot water.
Carefully add cold and salt water (tinted blue) into the tank.
The blue water will sink to the bottom and we will have two distinct layers of water in the tank, with a clear surface between them.



EXPERIMENT 2B: EL NIÑO Y LA NIÑA

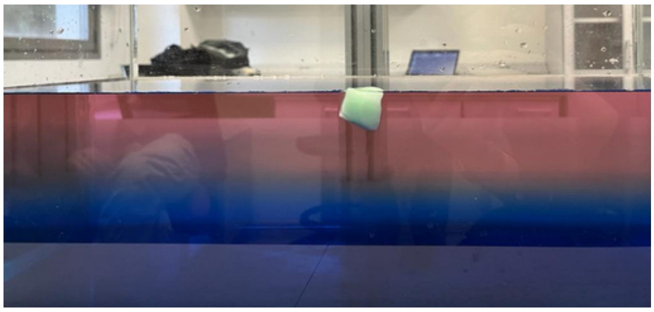
Place a small fan on the sides of the fish tank. The red water will move in the direction of the wind while the deeper blue water will rise in the opposite direction.
This is called an "upwelling" and allows the deep water to reach the surface.

FLOATING ROCKS AND RIVERS IN THE OCEAN: ICEBERGS AND OCEAN THERMOHALINE CIRCULATION

TUTORIAL

EXPERIMENT 3: MELTING ICEBERGS

Fill the fish tank of red, hot water.
Add the block of black ice and observe how it floats.
The water that melts from the ice will go to the bottom.
The iceberg turns upside down! Look at the shapes it forms.



EXPLANATION

Planet Earth is largely covered by oceans that go from the polar zones to the tropics. The ocean appears as a homogeneous mass of water, however, the difference in density between the different sea basins gives rise to water flows called marine currents. In the polar areas, the densest waters, due to their lower temperature and/or higher salt content, sink into the water column until they fill the deepest areas of the ocean. While the warmer and/or sweeter waters of the tropics are less dense, they occupy the uppermost layers of the ocean and end up moving to take the place of the sinking waters. This mechanism gives rise to a kind of conveyor belt that we call thermohaline circulation. The term thermohaline derives from the Greek words "thermos" which means "hot" and "halos" which means "of salt". Temperature and salinity are the factors that determine the density of water.

When the water gets cold enough, it ends up giving rise to ice. One of the most amazing physical properties of water is that its solid form, ice, is less dense than its liquid form and therefore floats on the surface of the sea. When these ices are large they are called ice floes or icebergs.
Icebergs are formed mainly in Greenland and Antarctica when they break off from huge continental glaciers that flow into the ocean. A rise in sea level can destabilize Antarctic coastal glaciers, whose base is below sea level very quickly. Icebergs drag stones from the continent that end up being thrown to the bottom of the sea when they melt. These rocks are preserved in geological sediments and allow geologists to reconstruct the evolution of the polar caps.

FLOATING ROCKS AND RIVERS IN THE OCEAN: ICEBERGS AND OCEAN THERMOHALINE CIRCULATION

EXPLANATION CONTINUATION

This activity allows us to observe how the rise in sea level affects the masses of ice found in polar latitudes, how the different masses of water do not mix because they have different densities, how ice floats and how meltwater melts. sink.

- The difference in density causes the masses of water to organize themselves in the water column, with the densest being those that sink to the bottom.
- Ice, having a crystalline structure, has a lower density than water, which has no structure and is denser, so ice floats.
- The cold water from the iceberg melt is very cold and denser than surface water, so it sinks. The wind pushes the surface water that ends up moving, this space is filled by cold water.

POSSIBLE QUESTIONS

- What do you think will happen with the Antarctic continent when sea level rise?
- How will take place the melting of the ice sheet? Why?
- What is the composition of the icebergs? Fresh or salty water? Meltwater from icebergs will be on the surface or will go to the bottom of the tank?

FURTHER INFORMATION

https://www.youtube.com/watch?v=jKS2MYjertE
https://www.youtube.com/watch?v=jOVvXDI0KbY
https://www.youtube.com/watch?v=f2evaLaDvCI

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutorial created by the students of the project. Follow this link https://youtu.be/RpRukEsPoV0 or scan the QR code.

STALACTITES AND STALAGMITES AS INDICATORS OF CLIMATE CHANGE

SUBJECT
ENVIRONMENTAL SCIENCE

TOPICS
#STALACTITES AND STALAGMITES
#CLIMATE CHANGE #EVOLUTION
#ENVIRONMENT #MINERAL PRECIPITATION

OBJECTIVES

- Know these silent witnesses that help to discover the history of climate
- Raising awareness about climate change
- Learning how these materials originate
- Recognize their mineral composition

LEARNING SCENARIO

Groups: Maximum of 15 students.
5 groups (3 students per group).

Time needed: 3-4 hours approx.

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

Experiment 1: **Speleothem formation**
About **40 cm of wool yarn**
A **pitcher**
Two glasses
A **flat dish**
Some **paper clips**
Magnesium sulfate (English salt)

Experiment 2: **Mineral precipitation “Chemical Gardens”**
Glass vials
Water
Sodium silicate (Na_2SiO_3)
Pellets/crystals of **metal salts**

Experiment 3: **Mineral precipitation “Rings of Liesengang”**
Glass tubes
Agarose (heteropolysaccharide)
Potassium chromate (K_2CrO_4)
Copper sulphate ($CuSO_4$)

Experiment 4: **Mineral precipitation “Tartaric Acid System”**
Glass tubes
Sodium silicate (Na_2SiO_3)
Tartaric acid ($C_4H_6O_6$)
Calcium chloride ($CaCl_2$) or **Cooper chloride** ($CuCl_2$)

Experiment 5: **Mineral precipitation “Crystallization of Glycine”**
Glass tubes
Glycine ($C_2H_5NO_2$)
Ethanol (C_2H_6O)

Experiment 6: **Mineral precipitation “Crystallization of salt and gypsum”**
Wide **glass tube**
Salt ($NaCl$) or **gypsum** ($CaSO_4$)
Parafilm

STALACTITES AND STALAGMITES AS INDICATORS OF CLIMATE CHANGE

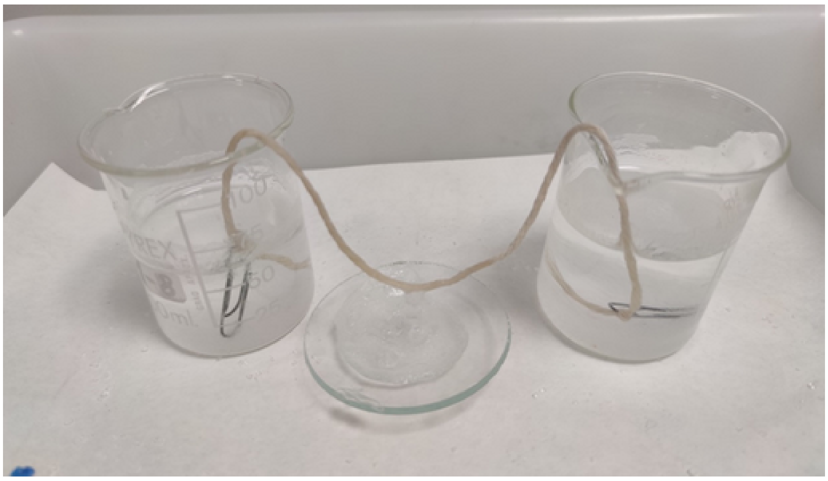
TIPS AND TRICKS

This activity allows us to observe the formation of these materials (stalactites and stalagmites) by accelerating the process to achieve the precipitation of crystals. To do this, a salty solution (magnesium sulfate, instead bicarbonate that precipitate slowly) is used, which rises along the wire by capillarity and falls drop by drop into the flat dish. Doing this in a warm room favors the precipitation.

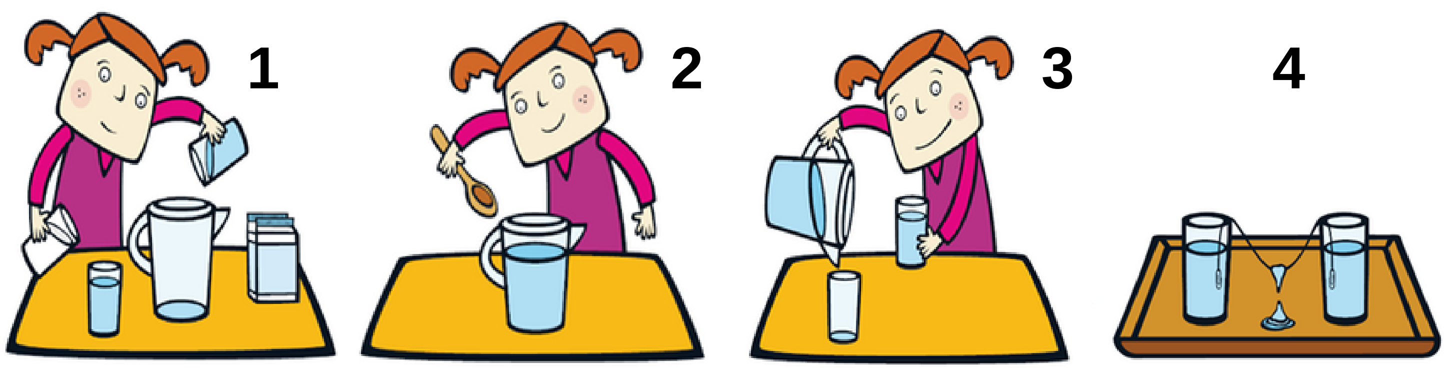
TUTORIAL

EXPERIMENT 1: SPELEOTHEM FORMATION

Pour two glasses of water into the pitcher, and add a whole glass of English salt (1). Stir until a thick liquid is formed (2). Now fill the two glasses with this liquid, and place them on the table, about twenty centimeters away from each other (3). Tie a pair of paper clips which will act as a "plum line" to the two ends of the thread. Drop one end into each cup, so that the string hangs down as shown in figure (4).



And wait a few days: this experiment requires patience.
What will happen? The thick liquid that you prepared will be climbing from the glasses to the thread. In the center it will start to drip, forming crystals. The ones that hang down are called stalactites; the ones that rise from the source and take a little longer to form are called stalagmites. The water in the solution evaporates slowly, forming the salt crystals.



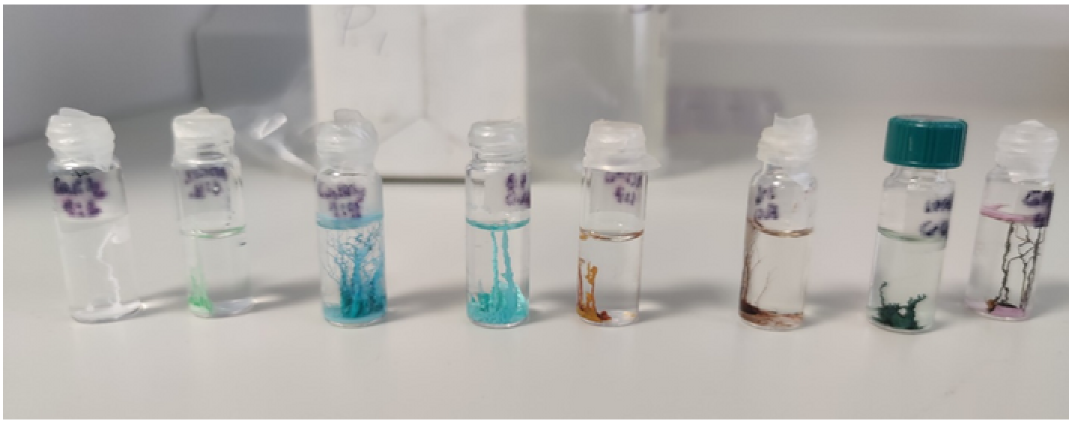
STALACTITES AND STALAGMITES AS INDICATORS OF CLIMATE CHANGE

TUTORIAL CONTINUATION

EXPERIMENT 2: MINERAL PRECIPITATION "CHEMICAL GARDENS"

Formation of self-organized crystalline patterns in nature: The coupling of mass transport and precipitation in diffusion-reaction systems produces self-organized patterns of interest in the nature that can be used as indicators of formation conditions.

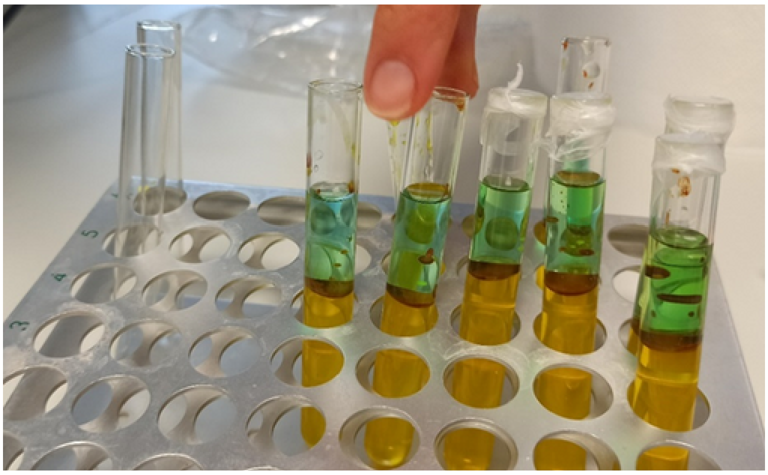
1. Prepare a solution: 4 parts of water + 1 part of Sodium silicate (Na2SiO3) 1.39 gr/ml.
2. Shake for at least 30 minutes.
3. Add pellets or crystals of metal salts with valence 2: NiCl2, CoCl2, ZnCl2, CrCl3, CaCl2, FeCl3, FeCl2, CuCl2, etc.



EXPERIMENT 3: MINERAL PRECIPITATION "RINGS OF LIESENGANG"

Formation of self-organized crystalline patterns in nature: The coupling of mass transport and precipitation in diffusion-reaction systems produces self-organized patterns of interest in the nature that can be used as indicators of formation conditions.

1. Dissolve 1% agarose in water at 86ºC.
2. Mix with Potassium chromate (K2CrO4, 0.1M) in equal parts.
3. Pour into a test tube and allow to gel.
4. Add Copper sulphate (CuSO4, 0.25M) to the tube.

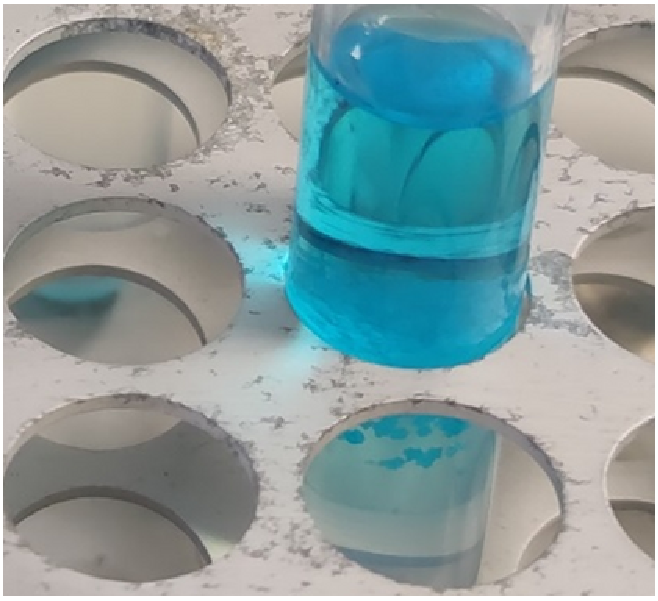


STALACTITES AND STALAGMITES AS INDICATORS OF CLIMATE CHANGE

TUTORIAL CONTINUATION

EXPERIMENT 4: MINERAL PRECIPITATION "TARTARIC ACID SYSTEM"

Nucleation and growth under diffusive mass transport conditions: The behavior of the crystallization process under conditions of absence of convection and microgravity is investigated using porous materials. Eliminating the chaotic convective component, it is possible to design experimental methods (called the "counter-diffusion" technique) where the material input is predictable and self-regulated. Diffusive environments/materials allow us to obtain crystals of optimized quality and size.

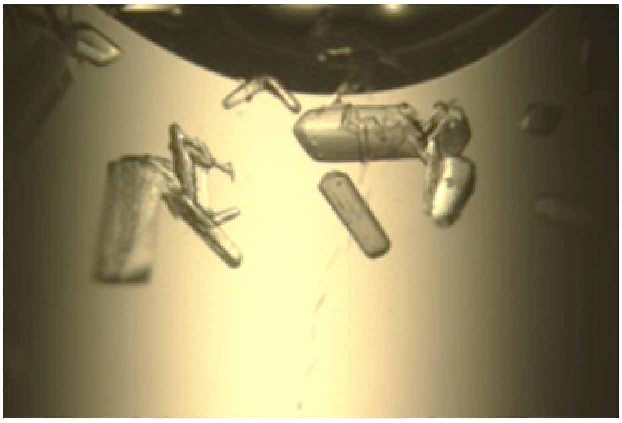


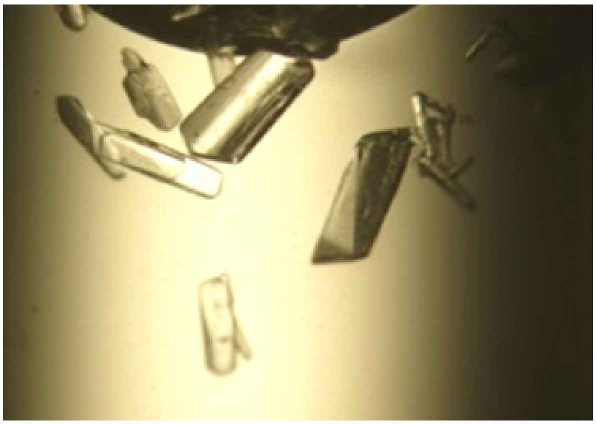
1. Prepare 10 ml of a 1.06 g/ml solution of Sodium silicate (Na2SiO3).
2. Mix with 5.15 ml of Tartaric acid (C4H6O6, 1M).
3. Pour into a test tube and wait for it to gel.
4. Pour in Calcium chloride (CaCl2, 1M) or Cooper chloride (CuCl2, 1M).

EXPERIMENT 5: MINERAL PRECIPITATION "CRYSTALLIZATION OF GLYCINE"

Crystallization of glycine: Using this technique we nucleate crystals by reducing the solubility of the compound by adding an antisolvent.

1. Prepare a 0.25 g/ml solution of glycine (C2H5NO2).
2. Pour it into test tubes.
3. Add ethanol (C2H6O) drops until precipitation is observed.





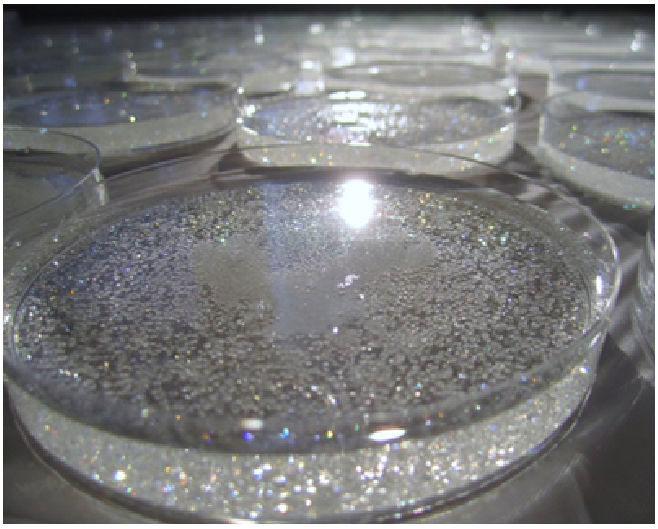
STALACTITES AND STALAGMITES AS INDICATORS OF CLIMATE CHANGE

TUTORIAL CONTINUATION

EXPERIMMINERAL PRECIPITATION “CRYSTALLIZATION OF SALT AND GYPSUM”

Crystallization of salt (NaCl) and gypsum ($CaSO4$): Using this technique we nucleate crystals by reducing the solubility of the compound by reducing the temperature.

1. Prepare a saturated solution with salt or gypsum (NaCl or $CaSO4$).
2. Reduce the temperature of the solution and nucleate crystals.



EXPLANATION

Speleothems originate from water dripping from the ceiling of the cavity.
The shape and size of the stalagmites/stalactites depend on many factors: distance to the drip point, drip flow rate, amount of bicarbonate in solution. They store a record of their chemical composition, which represents a fabulous archive of past climates and environments.
The reaction that takes place is one of dissolution-precipitation:
dolomite (insoluble) + water + carbon dioxide ↔ bicarbonate (soluble) + calcium + magnesium
$(CO_3)_2CaMg + 2H_2O + 2CO_2 \leftrightarrow 4(CO_3H)^- + Ca^{2+} + Mg^{2+}$

Its study allows us to know the climatic variation throughout the earth's history, which will allow us to reconstruct the past and deduce the existence of general trends in present and future climatic behavior.

STALACTITES AND STALAGMITES AS INDICATORS OF CLIMATE CHANGE

POSSIBLE QUESTIONS

- What is the relationship between climate change and speleothems?
- Why are they important and should we protect the caves?
- What is the mineral composition of the caves?

FURTHER INFORMATION

https://www.youtube.com/watch?v=eG9b_xOLXCE
https://www.youtube.com/watch?v=puA0YC-hSPM
https://www.youtube.com/watch?v=wFd3YmS-VBA
https://www.youtube.com/watch?v=M0cRnm2vv1Q

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutorial created by the students of the project. Follow this link https://youtu.be/7Hwgbanpvxk or scan the QR code

SEDIMENTS AND DEGLACIATION

SUBJECT
ENVIRONMENTAL SCIENCE

TOPICS
#CLIMATE CHANGE #DEGLACIATION #GLACIAL #INTERGLACIAL CYCLES #MARINE SEDIMENTS #CHANGES IN THE EARTH MOTION AROUND THE SUN

OBJECTIVES

- Providing the students with a basic knowledge of natural causes of climate change and how climate changes over Earth's history are registered in marine sediments.
- Increasing concerns about extreme climate events and environmental perturbations that are causing very severe impacts on planet ecosystems and in our society.
- For older students: data collection and interpretation

LEARNING SCENARIO

Groups: whole class or smaller groups, experiment suitable for all ages with different levels of analysis.

Time needed: 45 minutes (preparation of ice cubes a few hours in advance).

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

Water tank similar to a fish tank

White sand

Black (or dark) **sand**

Several **ice buckets**

Ice cubes with dark sand

White play dough to simulate glacial ice sheets

Closed wire in the shape of an ellipse

Two small **balls**

TIPS AND TRICKS

- Prepare the ice cubes well in advance and add just a little bit of dark sand in the ice buckets, otherwise, the cubes will sink rapidly, and floating is important to observe melting.
- Sand must be clean, if you cannot buy it you can wash it yourself with water and filter it.

SEDIMENTS AND DEGLACIATION

TUTORIAL

- Short presentation including a few slides to explain why climate has changed over time and glacial-interglacial cycles. Also, which sediments deposit during these cycles.
- Use a closed wire in the shape of an ellipse and two small balls to simulate Earth and Sun to explain Earth's eccentricity, axial tilt, and precession.
- Prepare the water tank with white sand and ice sheets made of play dough.
- Put ice cubes with dark sand in the tank and observe the melting and sediment deposition.

EXPLANATION

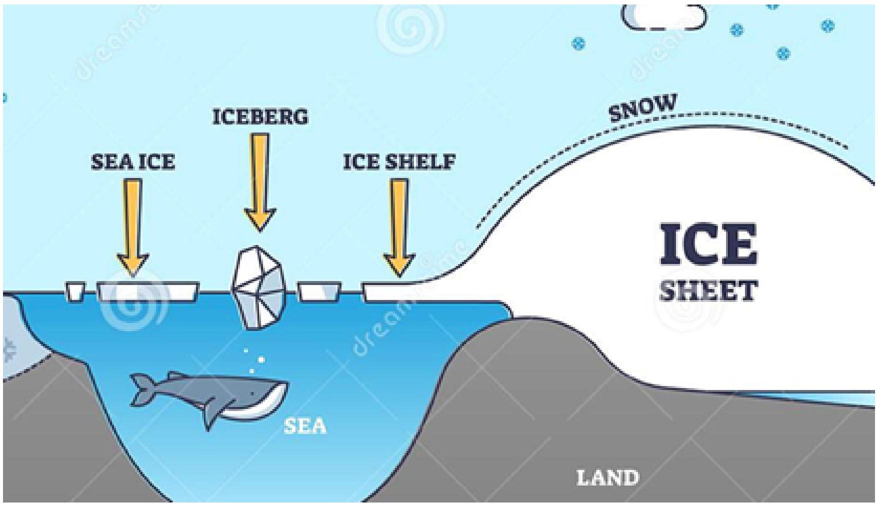
Marine sediments deposited on the ocean floor provide evidence of changes in Earth's climate. Both continental and marine sediments are markers of the Earth’s environment when they were deposited. Thus, they have registered how the environment of our planet has changed, including how climate has changed over time.

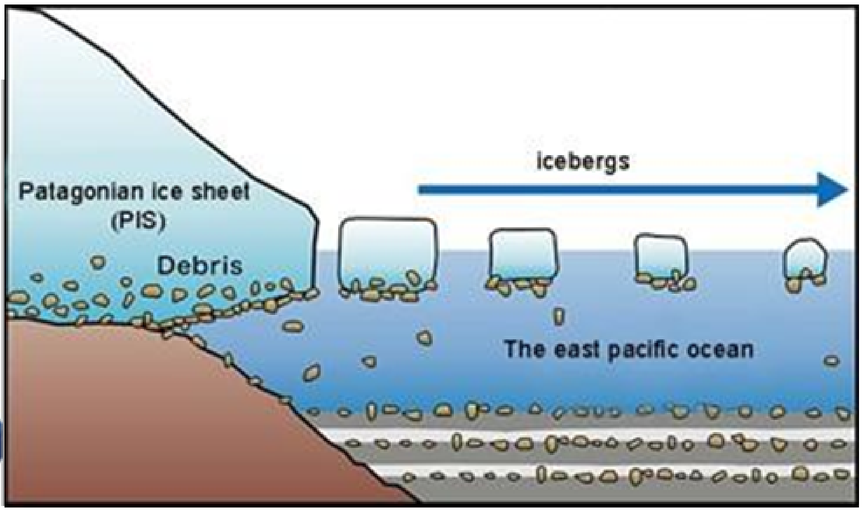
Some of the most significant climate variations in Earth’s history are the glacial- interglacial oscillations. Glacial-interglacial cycles have been driven by changes in the orbital pattern of the Earth (Earth's eccentricity, axial tilt, and precession) that have periods of about 20 ka, 40 ka and 100 ka. These cyclic variations are known as Milankovitch cycles and they determined the distance between the Earth and the Sun. These Cycles impact the seasonality and location of solar energy around the Earth. Changing the distance to the Sun determine how long the radiation travels to reach Earth, subsequently reducing or increasing the amount of radiation received at the Earth's surface in different seasons.

Understanding the causes of natural climate changes is important to understand our climate system, in particular when and why climate changes, and also helps to assess the human impact on climate variability, one of the greatest challenges for modern society. At present not only scientists but society in general is gaining awareness of the urgent need to limit climate change effects and understand the causes and effects of climate change. To do so, marine sediments are exceptional archives that can provide diverse information on past climate scenarios.

Ice sheets are highly sensitive to fluctuations in temperature. Colder temperatures and moisture-bearing winds have resulted in larger ice sheet, while warmer temperatures result in glacial melting. Both have left an imprint in marine sediments. Changes in sediment composition can therefore tell us how and when climates have changed in the past and in turn provide insights to further understand global climate and future climate change scenarios.

SEDIMENTS AND DEGLACIATION





POSSIBLE QUESTIONS

- Why do ocean sediments change between glacial and interglacial periods? (Formulate hypotheses and verify them with the model).
- How can we collect samples?
- How can we analyze them?
- Is climate change "bad" or "good"?

Depending on students' age, complex data might be provided to support their discussion.

SEDIMENTS AND DEGLACIATION

FURTHER INFORMATION

After collecting samples from the sea floor, they are prepared and analyzed in several ways:
- X-rays fluorescence. Clay and carbonates need to be removed first, then the sample is molten to form a transparent slide.
- Mass spectrometry. Samples are dissolved with a strong acidic mixture. Some additives might be needed to increase resolution.

In most cases, students will not be able to do this for real, but teachers can design experiments that simulate some of the stages e.g., carbonates removal, melting, acidic dissolution etc.

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutorial created by the students of the project. Follow this link https://youtu.be/pFi4351fYOU or scan the QR code

MICROBIAL DIVERSITY IN SOIL AND PLANTS

BOOSTING GREEN EDUCATION

SUBJECT
ENVIRONMENTAL SCIENCE
MICROBIOLOGY

TOPICS
#ECOSYSTEMS #MICROBIOMES #PLANT GROWTH #SUSTAINABLE AGRICULTURE

OBJECTIVES

- Learning about the soil microbiome
- Learning about plant-associated microorganisms and their role in plant health
- Detecting antimicrobial activity

LEARNING SCENARIO

Groups: Students can work in groups, each focusing on a particular environment:
1) Soil (this can be divided to test different types of soil, e.g., garden, park, beach sand, etc.).
2) Plant root surface and associated soil (the rhizosphere).
3) Aerial part of plants (the phyllosphere).

Time needed: 1-2 h during 3 days

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

Sterile saline solution (NaCl 0.9%, can be obtained from a local pharmacy).
Sterile plastic containers (e.g., containers for taking urine samples, also available at local pharmacies).
Plastic bags with zip lock
Test tubes
Small graduated **beaker** or 10 ml **pipettes**
Spatula or small **spoon**
Tweezers
Razor or **knife**
Weighing scales
Disposable **Pasteur pipettes** (if available, variable volume micropipettes)
Petri dishes with any nutrient-agar medium (alternative or expansion: **Pikovskaya**'s agar, for phosphate solubilization; King's B medium for detection of siderophores)
Ethanol
Burner
Loop or **spreader** (alternatively, glass beads 3 mm diameter)
Permanent **marker**

MICROBIAL DIVERSITY IN SOIL AND PLANTS

TIPS AND TRICKS

- Glass beads (3 mm diameter) can be easier to use to inoculate Petri dishes than the spreader and are reusable by sterilizing them with 70% ethanol.
- If agar medium is hard to obtain or too expensive, you can try using slices of cooked potatoes. The details are also provided in the tutorial.
- Always work in a clean environment. If possible, use a Bunsen burner to create a sterile area while working. Otherwise, clean all surfaces with 70% ethanol.

TUTORIAL

STEP 1	Divide students into different groups and assign them a specific environment to study. Different samples from each environment can be taken.
STEP 2	Use sterile containers and collect samples from the selected origins as indicated below. Small amounts (around 4 g) are sufficient. a) Soil samples: dig to about 1 cm depth and collect the sample with a spatula or mall spoon, putting it in a plastic container. Take notes of the area, and soil characteristics (e.g., sandy or clayey, moisture, texture, compactness). b) Plant material: select a small plant growing in a pot or a garden, remove it carefully (some digging around is usually required), shake off the excess soil attached to the roots, and place it in a plastic bag.
STEP 3	Processing <u>soil</u> samples. 1. Weight the material, place 1 g in a screw-cap tube or container and add 10 mL of sterile saline solution [If you use monodose saline solution vials, they usually contain 5 mL; simply use 2 vials]. Shake vigorously, and let it sit for 10 minutes. Store the rest of the soil sample in the dark. 2. With a Pasteur pipette, transfer 5 drops (around 100 µL) directly to a Petri dish containing the growth medium. Avoid carrying excess solid material. Spread the liquid all over the surface with a spreader or around 10 glass beads, until you notice the surface dry. Label the plate as 10^{-2} (see explanation below). 3. Transfer another 5 drops to a clean tube containing 10 mL of saline solution. Mix well and proceed as in 3.2. Label the plate as 10^{-4} (see explanation below). 4. Place the plates in a 30°C incubator, if available, or in a dark, warm place. Incubate for 24h.
STEP 4	Processing <u>plant</u> samples. 1. Divide the plant into aerial and root parts by cutting it at the base of the stem. Weigh each part separately and record the weight. Place each part in a different container. 2. Add 10 mL of saline solution to each sample. Shake vigorously for 2 min, and let them sit for 5 min. 3. Proceed as in steps 3.2 to 3.4.

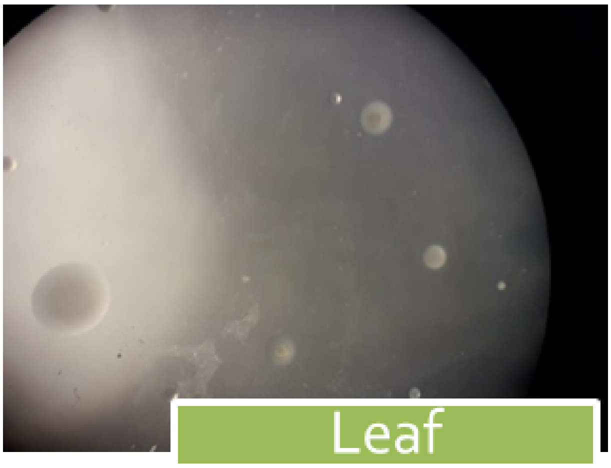
MICROBIAL DIVERSITY IN SOIL AND PLANTS

TUTORIAL CONTINUATION

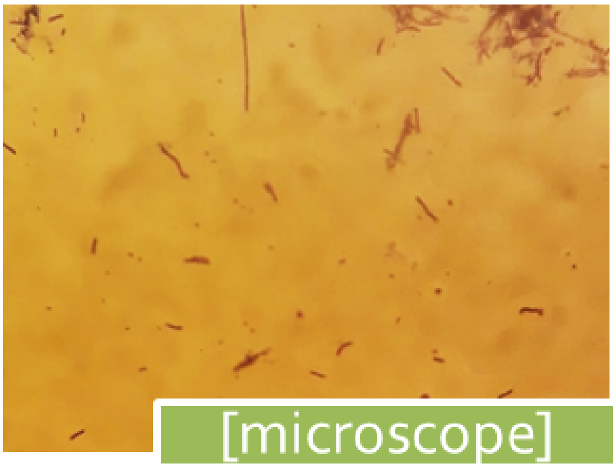
STEP 5	The following day, take out the plates. Count the number of total colonies in each sample, describe the types of colonies which appear with different morphology, color, etc., and count the number of each type. Both bacteria and fungi will likely grow. Take pictures, and if possible, a stereomicroscope can be used for closer inspection.
STEP 6	Compile the data from each sample, to determine: • The abundance of microorganisms in each type of sample (total number of colonies), calculating the number of colonies per gram of sample. Take into account the dilutions made before plating (see explanation). • The diversity in each sample (the number of different types of colonies). Again, refer to the gram of the sample. • Is there a particular type of colony that predominates in a sample? • If specific media were used, check for phosphate solubilization or siderophore production (see explanation).

Soil

Root



Leaf



[microscope]

MICROBIAL DIVERSITY IN SOIL AND PLANTS

EXPLANATION

Microorganisms are present in nearly all environments on Earth. They are particularly abundant in soil and associated with plant roots, where they can obtain nutrients from the plant. With this experiment, students can check the abundance and diversity of microorganisms in these environments.

Bacteria will multiply and form colonies on agar medium, each colony being derived from one individual bacterial cell. Many microorganisms can also grow on potato slices, as well as other nutrient-rich agents, and this was in fact the method used by early microbiologists before agar was routinely introduced as a gelifying agent for broth media.

This is the basis to determine how many microorganisms are present in the samples, and normalize the data, e.g. per gram of starting material. For these calculations, we have to take into account the dilutions made to inoculate on plates. For the soil samples, for example, we started with 1 g in 10 mL of saline solution. We inoculated 100 µL in the first plate (10-2; one drop of the Pasteur pipette corresponds approximately to 20 µL), so the number of colonies will have to be multiplied by 100 to determine the initial number (if we have X colonies in 0.1 mL, how many in 10 mL?). In the second dilution (10-4), we should obtain around 100 times less colonies than in the first one. The reason for doing two dilutions is to ensure we can count the colonies, in case the first one contains too many bacteria.

The use of specific growth media can allow identifying functions that can be beneficial for plants. King's B medium is used to detect the production of fluorescent siderophores, molecules that can trap iron from the surrounding medium to be taken up by the bacteria that produce them, but also by plants. Pikovskaya's medium is used to identify bacteria capable of solubilizing phosphate, which can be used by plants, reducing the need for chemical fertilizers. Phosphate solubilization is detected as a clear halo around a colony.

POSSIBLE QUESTIONS

- Why use a physiological solution (NaCl 0.9%)?
- What is the meaning of using a growth medium?
- What temperature range should be used to incubate these bacteria? Why?
- Why do we spread the suspension all over the plate surface?
- How do we see the diversity in these environments?
- Why do we use ethanol to prepare plant extracts?
- How can we distinguish if the antimicrobial activity is due to the plant or to microorganisms associated with them?

MICROBIAL DIVERSITY IN SOIL AND PLANTS

FURTHER INFORMATION

Two additional experiments can be incorporated into this activity:

1. Place parts of plants on Petri dishes containing rich nutrient medium: a leaf, part of the root, etc. Press the material lightly on the medium surface and incubate overnight. Then remove the plant material and observe the colonies that have grown.
2. You can also try to isolate endophytes (microbes growing inside plant tissue). For that, the plant should be soaked in 70% ethanol for 5 minutes. Allow it to dry and then cut pieces of around 1 cm from the root and stem. Proceed as in steps 4.2 onwards.

https://ucc.eez.csic.es/high-school-students-for-agricultural-science-research-volume-6/
https://ucc.eez.csic.es/high-school-students-for-agricultural-science-research-volume-4/
https://www.youtube.com/watch?v=72tXTrSXoMk
https://www.youtube.com/watch?v=Hja0SLs2kus

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutorial created by the students of the project. Follow this link https://youtu.be/Ul0IVEEPQWM or scan the QR code

COMPOSTING IN A BOTTLE

SUBJECT
ENVIRONMENTAL SCIENCE
AGRICULTURAL SCIENCE

TOPICS
#RECYCLING #COMPOST #COMPOSTING #BIO-WASTE #CIRCULAR ECONOMY #ORGANIC FERTILIZER

OBJECTIVES

- Learning about bio-waste production
- Learning what compost is and how it can be done at home or at school
- Exploring the biological insight of composting
- Learning the importance of the organic matter in agricultural soil
- Learning an easy way for recycling

LEARNING SCENARIO

Groups: The experiment can be done in small groups of 3-5 students. They can work independently or coordinately in 3 groups:
- Soil team
- Leaves team
- Food waste team

Time needed: It is a long-time experiment (2-3 months), with measurements every week.

MATERIALS AND INSTRUMENTS TO MAKE ONE EXPERIMENT

3 **clear plastic bottles** of 5 L
Electric drill, punch tool or something similar to make small holes in the plastic bottles
A **plastic container** of 20 L or similar
Scissors
Soil from the school garden **[S]**
Dry leaves from the school garden **[L]**
Food and **kitchen residues** collected from our homes or from scholar restaurant (mainly fruit peels and vegetable scraps) **[FW]**
Manual portable **luggage scale**
Digital thermometer with a probe
Garden shovel
Permanent marker
Meter ruler
pH meter
Spoon
Balance (precision of 0,1 g)
Petri dishes with growing media **[TSA]** (https://www.amazon.com/Tryptic-Agar-Plates-Evviva-Sciences/dp/B07RWH9RYX)
Glass beads and **ethanol** for their disinfestation
100 mL tubes or similar
Seeds of horticultural plants (it depends on geographical localization)

COMPOSTING IN A BOTTLE

TIPS AND TRICKS AND SAFETY

- In order to avoid insect proliferation, the last layer added to the composting bottles has to be soil, which will cover the food scraps.
- During composting, store the composting bottles inside a room to avoid temperature changes. No direct solar light is recommended.
- During the plant experiment, store the composting bottles inside a room to avoid temperature changes (a greenhouse will be great). Direct solar light is strongly recommended.
- To take samples, remove carefully the upper leaves layer.

TUTORIAL

PREPARE COMPOSTING BOTTLES:

STEP 1	Collect 3 kg of soil, 3 kg of dry garden leaves and 3 kg of fruit peels and vegetable scraps.
STEP 2	Chop garden leaves, and fruit peels and vegetable scraps into small size using the scissors.
STEP 3	Prepare the composting bottle: Divide the water bottles in two parts: the former will be used as the base and to collect leachate (Part A) and the latter, to store the composting mixture (Part B) (Figure 1). Make small holes in Part B randomly, especially at the bottom, for slurry collection to ensure aeration of the composting mixtures.
STEP 4	Three composting treatments will be assayed: a. Only soil **[S]**. b. Soil + garden leaves **[S+L]**. c. Soil + garden leaves and food waste **[S+L+FW]**.
STEP 5	<u>Fill the **S** composting bottle:</u> Add soil to Part B until 80 % of the Part B volume capacity.
STEP 6	<u>Fill the **S + L** composting bottle</u>: Add equal volumes of soil and dry leaves to a container and mix them with the Garden shovel. Fill Part B until 80 % of its volume capacity.
STEP 7	<u>Fill the **S + L + FW** composting bottle</u>: Add equal volumes of soil, dry leaves and food waste to a container and mix them with the Garden shovel. Fill Part B until 80 % of its volume capacity.
STEP 8	Add leaves as the last 2-3 cm layer to each composting bottle to cover the food scraps.

COMPOSTING IN A BOTTLE

TUTORIAL CONTINUATION

STEP 9	Add 200-300 mL of tap water to composting mixtures to ensure a moisture of 30-40 %.
STEP 10	Mark the composting mixture position in Part B with a permanent maker and measure the initial height (cm) with a meter ruler.

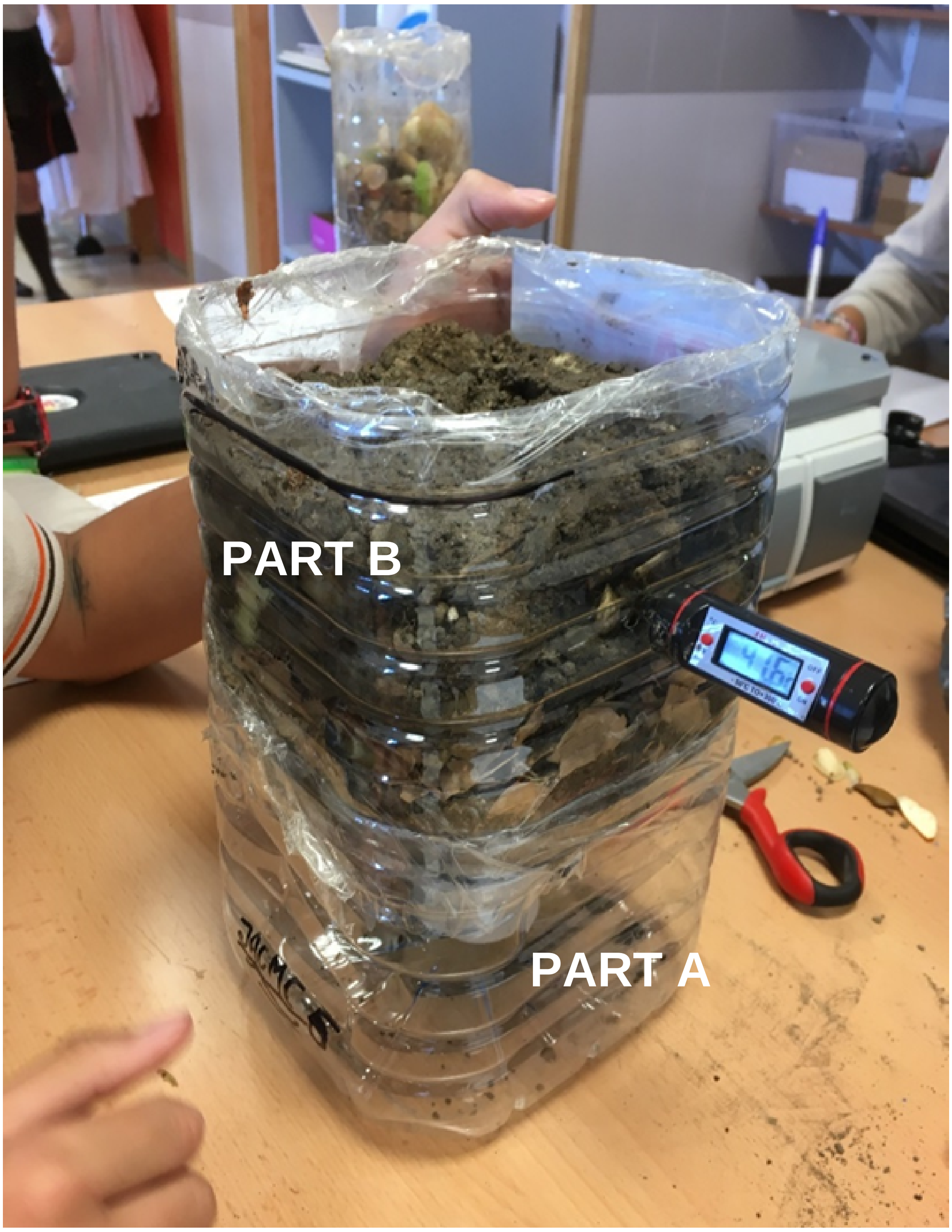


Figure 1. Composting bottle.

COMPOSTING IN A BOTTLE

TUTORIAL CONTINUATION

EXPERIMENT 1: STUDY OF THE COMPOSTING PROCESS

1) Every week, measure the mass evolution (kg) of every composting bottle by using a manual portable luggage scale.
2) Every week, measure the temperature evolution (ºC) of every composting bottle by using a digital thermometer with a probe. Insert it in at least 5 holes in Part B. Also, register ambient temperature.
3) Every week, measure the height evolution (cm) of every composting mixture by using a meter ruler.
4) All measurements need to be done at least within 2-3 months.

EXPERIMENT 2: PH EVOLUTION

To be done every 15 days during the composting experiment.

- Add 5 g of compost mixture in a 100 mL tube.
- Add 50 mL of tap water.
- Mix the tube vigorously for 1 min.
- Wait 5 min for gravity sedimentation of the slurry.
- Transfer the supernatant carefully to a new tube.
- Measure the pH with the pH meter.

EXPERIMENT 3: BACTERIAL DIVERSITY IN COMPOSTING MIXTURE

To be done at the beginning of the composting experiment, in the middle and at the end.

- Add 1 g of composting mixture 50 mL sterile tube.
- Add 5 mL of saline solution (NaCl 0.9%, w/v) and mixed vigorously
- Wait 10 min until gravity sedimentation of the slurry.
- Add one drop into Petri dishes containing a general growing solid media for bacteria (TSA medium).
- Add 2 mm glass beads to Petri dishes and shake them for 1 min.
- Remove glass balls and incubate at room temperature during 24-48 h.
- After that, count the number of colonies among treatments and compare them.

A similar protocol can be found in “Microbial diversity in plant and soils” activity sheet.

COMPOSTING IN A BOTTLE

TUTORIAL CONTINUATION

EXPERIMENT 4: EFFECTIVENESS OF COMPOST AS ORGANIC FERTILIZER

To be done at the end of the composting experiment.

- Plant 5 seeds of any horticultural plant inside Part B of each composting bottle. Introduce them at 2-3 cm of the upper layer.
- Add 200-300 mL of tap water.
- Place the composting bottles inside a room to avoid temperature changes. Direct solar light is strongly recommended.
- Similar to a pot, plants will be grown during 3-4 weeks.
- At the end of the experiment, plant height and weight will be measured.

EXPLANATION

The generation of organic waste is directly related to human activity and as a consequence, these residues are increasing. Bio-waste is an example of such organic waste, which includes garden and park cuttings and food and kitchen waste from households and catering establishments, among others.

Composting is a feasible methodology for bio-waste management. It is defined as a controlled bioxidative process, in which the organic waste is transformed by the own microorganisms of the raw waste. The bioxidative process is the most active stage, where important organic matter degradation, CO_2 emissions and microbial activity take place.

Composting bio-waste is a feasible strategy to both reduce the environmental impact of bio-waste generation and to produce high-quality organic amendments which can be used for increasing the organic matter within soils.

BOOSTING GREEN EDUCATION

COMPOSTING IN A BOTTLE

POSSIBLE QUESTIONS

- Why does the mass of the composting mixture is reduced during the process?
- Why does the volume of the composting mixture is reduced during the process?
- Why does the temperature of the composting mixture rise during the process?
- Why does the pH decrease at the begging and rise up at the end of the process?
- Why does food waste increase biological diversity?
- Why does compost improve plant growth?

FURTHER INFORMATION

https://ucc.eez.csic.es/wp-content/uploads/2018/09/HSSASRv7.pdf
https://ucc.eez.csic.es/wp-content/uploads/2020/06/HSSASRvolume9.pdf
https://cwmi.css.cornell.edu/compostingintheclassroom.pdf

LET'S TRY IT!

You can replicate the laboratory with the support of the videotutorial created by the students of the project. Follow this link https://youtu.be/FKRuAKB9vDg or scan the QR code

ANNEX - THE IBSE METHOD AND ACTIVITY SHEETS BASED ON IBSE

NATURE OF THE METHOD

Inquiry-based science education (**IBSE**) - that means **teaching science through inquiry** - is a pedagogical method that places children's ideas, questions, and observations at the center of the educational experience [1]. Using this method, both science communicators (in general, educators) and children (the students) share responsibilities in the learning process: the freedom to research how certain phenomena occur, **through experience and comparison** with one's peers, is manifested in the responsibility for the construction of collective knowledge [2].

Together, **educators and students construct the learning experience**, accepting mutual responsibility in the design, judgment of the various stages of learning and improvement of the individual, as well as in that of the whole class. This peculiarity of the IBSE method implies **greater commitment** during the educational experience, both on the part of the children and on the part of the communicators: the first is required to take an **active part** in defining the path of inquiry, and the second is required to have the **ability to re-learn** at each step with the children.

FOR STUDENTS: FREEDOM AND RESPONSIBILITY

As for the children, the method, which usually involves the **"free" investigation of a problem** (not only scientific), requires them to engage in reasoning based on experimental and factual evidence. Indeed, the very construction of knowledge takes place in the exploration, investigation and study of natural phenomena in which the learner is immersed, of which he or she has daily experience, and not in the passive acceptance of a legacy from the educator ("the adult who knows") [3].

While in the "depository" conception, the educator "fills-in" the students with knowledge (which are the imposed contents), in the **problematizing practice**, the students develop their capacity to grasp and understand the world, which appears to them, in the relationships they establish, no longer as a static reality, but as a process. This means that students and educators **establish an authentic form of thinking and acting**. Thinking about oneself and the world simultaneously, without separating the thought from the action.

Problematizing education thus becomes an ongoing effort through which humans critically perceive how they "are in the making" in the world, with and in which they are.

Members of the study group (of the class, usually) discuss what they have learned from others, in a **mutual exchange**. From listening to the ideas and experiences of others, the individual child comes to a better understanding of his or her ideas and how to deal with problems.

In contrast to the traditional method that focuses more on the notion, that is, the transfer of knowledge from the educator to the student by means of concepts (which are required to be simply accepted by the learner), **each student can contribute to a collaborative inquiry** from the perspective of the IBSE method, regardless of his or her initial ability and preparation, while developing a **critical consciousness**. Of course, individual contributions are usually uneven: there are students who may find it easier to ask questions and make other students' answers clearer; others may be better at making connections between the most important ideas that emerge during the research. It is in these cases that the **educator plays an important role**, with his or her ability to unblock possible stalemates in the inquiry carried out by students and to stimulate them to ask questions and analyze what has been observed.

FOR EDUCATORS: THE ABILITY TO RE-LEARN

As for educators, the **IBSE method** requires them to be responsive to children's learning needs, to know when and how to introduce students to key ideas and concepts that will move them forward in their inquiry.

In other words [3]:

Educators do not simply transfer notions to students but encourage them to learn through critical reflection, problematization, and discussion. Instead of being docile receivers of information, students are now **critical researchers**, **in dialogue with the educator**, **who is also a critical researcher**.

Educators, minimizing the notionistic approach in favor of inquiry guided essentially by the students' proposals, try to create an environment in which **students can respectfully confront one another**, discuss their ideas, critique them, find a way to test them, and therefore develop and refine them.

Educators also have the delicate task of **pushing students beyond their natural curiosity** toward a more regular, more analytical path of inquiry; they help to extend the ideas that emerge from individuals, help to challenge and ask questions about how to carry out investigations regarding the individual's ideas or the theories obtained collectively. In short, we might say that **educators play the dual and seemingly contradictory role of "mediators" and "provocateurs"**, seeking new ways to expose students to ideas and topics that might be of interest to them, and to show their potential as investigators.

In doing so, the children, moving from an initial condition of wonder and surprise (still indispensable to the quest for knowledge) come to an **increasingly firm construction of understanding**, precisely because it is based on experience and comparison with their peers.

KEY POINTS

In short, we could thus operationally condense the **IBSE method**:

1. We put **students' ideas and reasoning at the center of the discussion**, developing with them the initial path they outlined and thus the investigation that follows;
2. We create an **environment for respectful discussion**, we value everyone's input;

3. We intervene to **push students to make their own contributions to the investigation**, making sure that students are clear about the ideas discussed and pay more attention to key concepts;
4. We **develop questions** with them that arise spontaneously to interest them even more in the topic and ask them further questions;
5. We give **instruction** or do **mini-lessons** when it is evident that students need some new tool or concept to progress.

PHOTOSYNTHESIS IN A JAR

SUBJECT
ENVIRONMENTAL SCIENCE

TOPICS
#ECOSYSTEMS #PHOTOSYNTHESIS #FOREST LOSS #CLIMATE CHANGE #OXYGEN PRODUCTION #LIFEANDBIOSPHERE

OBJECTIVES

- Learn how plants photosynthesize

- Learn about deforestation and its effects on climate and ecosystems

LEARNING SCENARIO

We suggest approaching the experience as a 3 IBSE level, so a guided inquiry.
By the way, the teacher should adjust the level on the way.

EXPERIMENT DESCRIPTION

ENGAGE

Show links from previous works. Show news, maps, pictures. Teacher should decide what to show depending on the focus of the lesson.
Important questions to rise (to make connection with deforestation):

- Why do we need forests?
- What is the role of plants in forests?
- Why do we need them?
- Why and how humans have been using forests?

Find and show them data, graphics, photos, videos, news (from reliable and qualified sources).
You can for example search in:
https://www.ventusky.com/
https://app.electricitymap.org/map?wind=false&solar=false
https://earth.nullschool.net/
https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases
https://compostrevolution.com.au/
https://climate.nasa.gov/
https://www.ipcc.ch/
https://www.ted.com/talks/gavin_schmidt_the_emergent_patterns_of_climate_change#t-2113
https://www.youtube.com/watch?v=64R2MYUt394

PHOTOSYNTHESIS IN A JAR

EXPERIMENT DESCRIPTION

EXPLORE

Since it is a guided inquiry, give students the research question, e.g. "How to confirm/show that plants produce oxygen (using the equipment given)?". Then have the students sketch a device to collect oxygen from water plants with the items given to them. Later when the test tube is filled with oxygen, give the other question "How to test/confirm it is oxygen in the tube?"
For the experiment, split the class into groups (4-6 people), some groups should do the 'main experiment' and some groups the control experiments (non-transparent funnel, no plant).

EXPLAIN

Groups will analyze the experiment and report to the others (the teacher might distribute some tables/templates where they can write down their observations).

- What happens in the jar?
- Why are the bubbles forming?
- How are the bubbles moving?
- Describe the differences of the jars
- What is in the top of the test tubes?
- How can you check/test if the air in the top of the tube is oxygen?
- What happens with the flame (in each tube)?
- How to explain why the flame changes/does not change?

ELABORATE

Talking about the experiment in different contexts. Connection with real life. Origin and consequences of deforestation - links with the experiment. Reading the data from the experiment (density, pressure, etc.). Designing new experiments.

EVALUATE

Peer-evaluation, self-evaluation (how did we do as a team, as a person). Teacher evaluation - formulate questions that are related to the work students did (so you can test what they learned).

LIFE IN A JAR

Our planet recycles and reuses everything on it needed to support life. It's an amazing, giant recycling system called the biogeochemical cycle. You can actually model this on a small scale by using a plastic bottle and mud to build what's called a Winogradsky column, a visible stratified portion of the complex ecosystem of prokaryotic bacteria and archaea, distinguishable by observing their colors.
In this activity students will build their own columns and investigate how including different nutrients and physical resources affects soil microorganism.

OBJECTIVES

- Learn how to build a Winogradsky column
- Make observations on a long ongoing experiment
- Learn the interdependence of life forms on a microbial scale
- Water and soil contain a multitude of microorganisms, a combination of microbial metabolism and physical parameters (such as light availability and diffusion) can create a rich stratified ecosystem
- Microbes play a role in elemental cycling

LEARNING SCENARIO

Groups: small group activity, part outside and part in lab or in classroom.

Time needed: some hour to collect natural material, an hour to prepare the columns, at least 8 weeks to collect results.

Related topics: Microbiome, ecosystem, bacteria, natural cycle, biodiversity, environmental science.

INSTRUMENTS AND MATERIALS

The columns are easy to set up, quantity and required materials can vary, the experiment consists also in trying and exploring different types of columns.

Mud: from the bottom of a lake or river or a pond (take photo of that)
Water: from the same place where the mud is collected, if it is not possible tap water.
Material to enrich mud: a carbon source such as newspaper (containing cellulose) or egg-shells (containing calcium carbonate), and a sulfur source such as chalk (containing calcium sulfate) or egg yolk, coin (containing metals), salt.
Container: a glass tube, a jar or transparent container, (best if rigid) that will contain the mixture of mud and water, about 30 cm tall and 5 cm diameter but dimensions are not critical. In order to compare different columns at least 4 identical containers are needed.
Tools for digging the mud collect it and insert it into the bottle: showel, buket, gardener/plastic gloves, smaller container to mix mud and materials, funnel.
Instruments to record data: paper, pen, phone camera, post-it.

LIFE IN A JAR

EXPERIMENT DESCRIPTION

ENGAGE

Propose an **outdoor activity** to the class, with the aim of **collecting samples of living beings to create an ecosystem in the classroom**, ask the children what they would like to capture, they will mainly say vertebrates! Reflect together on the difficulty that this choice would entail. If not already done, this is a good time to introduce the concept of the importance of microbial life: **ask students if they think if life is possible under the ground, ask what they think happens to a dead animal or a rotten tree**. “Do you know the Futurama Bender experiment”.

Collect the sediment sample	
STEP 1	Identify a sediment source in your area. Anywhere with dirt and water is appropriate, such as a stream, creek, marsh, pond, bay, beach sand, a backyard puddle.
STEP 2	Take photographs of your sample site
STEP 3	Collect enough sediment to fill ¾ of your container in the bucket. The sample should be wet, including some additional water from the sample site
Assemble the Winogradsky columns	
STEP 4	Different containers will be enriched with different materials, separate mud in 4 equal part using four different disposable containers, each one of this mud will be part of a different column (you can add different “enrichment” but always remember to create a control column, with just mud and water) a) For the “carbon” column: Add some shredded paper (loosely packed and not plastified) to the sediment and mix, paper containing cellulose, a source of carbon. b) For the “sulfur” column: Add the yolk of an egg to the sediment and mix, egg yolk is a source of calcium sulfate. c) For the “carbon and sulfur” column: Add both enrichment and mix. d) For the “control” column: Do not add anything to the mud.
STEP 5	Mix each of the samples thoroughly. Try to remove any large debris such as leaves, rocks, or sticks. Slowly mix in water (either water that you collected or tap water) until the mixture has the consistency of a mud shake.

LIFE IN A JAR

EXPERIMENT DESCRIPTION

STEP 6	Using a large spoon, slowly fill your different columns until 3/4 of the column's length. We suggest using a funnel or a handmade one with a cut bottle top.
STEP 7	Half fill the remaining space with collected or tap water, leaving some air in the upper part, tap the column to release any trapped air in the mud, loosely close the column to avoid water evaporation and to prevent the material from falling due to accidental impact.
STEP 8	Label the columns with a permanent marker or a post-it, take a picture of the columns just made.

SAFETY CONCERNS

Though minimal, there are some safety concerns regarding the assembling and handling of Winogradsky columns. In most cases, if a person can be outside around soil, they should be able to be around and work with the columns. The vast majority of microbes in the environment are non-pathogenic and unable to grow in the human body, which is a very different environment.

However, it is advisable to always exercise caution when gathering samples and handling the columns. To maintain safe protocol, follow these simple cautionary steps, to limit growth of fungi and release of spores:

- keep the mixture in the columns moist with a layer of water on top
- make certain there is little to no organic material on top of the mixture
- do not breathe in directly over an uncovered column.
- Wear gloves when handling the sediment mixture and columns.

Columns must be stored with the lids loose. Gases produced by microorganisms can build up quickly and must be allowed to escape to avoid a build-up of pressure that may lead to column explosion. CONSIDER THAT THE MATERIAL INSIDE THE COLUMN CAN SMELL REALLY BAD.

LIFE IN A JAR

DATA GATHERING

ENGAGE AND CONNECT WITH OTHER SUBJECTS

The first experimental day columns will look identical, engage students asking how they suppose columns will differ after longer time.

It takes approximately 6 to 8 weeks to see layers of microbial growth, but the experiment can be conducted for a longer time period. If possible leave the column always in the same place. Spend a few minutes each week recording your visual observations of the columns and taking pictures of your experiment (shoot the picture always in the same light condition and write in the file name the date), **try to sketch the column, sketching encourages deeper observation of the columns and lead you to creates your personal bacterial Rothko**. Try to make each observation with an equal temporal distance. At the end of the data gathering campaign you will have created a table of your observations and a lovely photo-album of your miniature ecosystem. **Layers of bacteria can be represented as a fraction of the whole bottle, try to use this fraction as rhythm; each bottle will have a personal theme that evolves in time. Reflect how the environment affects the colonies, they affect each other and are affected by the enrichment material, imagine to be a bacteria in the bottle and write your bottle story or cosmogony**.

EXPLORE

When you gather the data consider this questions:

- What differences between the columns do you observe?
- Has the color of the sediment changed?
- Has the color of the water changed?
- Do you see any layers forming in the sediment? In the water? How do they stack up?
- How does the thickness of the layers change from week to week?
- Are there differences between the side facing the light and the side away from the light?
- Try to organize the color in advance and check if it works.

Varying the type of nutrients is just one of a number of different activities that can be done using the Winogradsky columns in the classroom. Students can manipulate variables to test microbial growth in different conditions and the teacher should guide the class to formulate investigable questions like “Which microbial populations will grow more?”, “How will the community structure be affected?” etc. As a good scientist, remember to evaluate your results with a control column which has the same features except the one that you are changing. Below are listed some variations easily explorable.

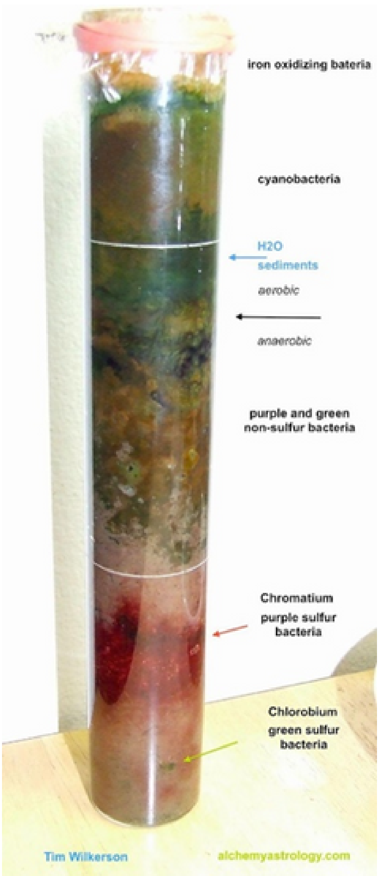
LIFE IN A JAR

DATA GATHERING

Amounts and types of nutrients.
Students can create columns with differing amounts of a single ingredient such as, sulfur, salt, cellulose, or phosphorus. For example, a column with a high sulfur concentration will likely support growth of purple sulfur bacteria more so than a column low in sulfur. Similarly, a column with high salt concentration will select for halophiles, and if there is no microbial growth in the column, it is likely that halophiles were not present in the initial sediment sample.

Different lighting.
Students can place their columns under different types of lighting. Place one column in a sunny windowsill and one in an artificial illuminated room. Try to to wrap all or part of the column in black construction paper or aluminum foil to test what occurs in the absence of phototrophy (and therefore limited oxygen and carbon fixation)

Different mud/water.
Students can explore using different muds, try to growth column from different collecting area, you can try less and more antrophized area versus natural ones, try to use gardening soil instead of mud, what are the differences from tap and "wild" water, try to use chlorinated water to show the deadly effects of chlorine on microbial life.



LIFE IN A JAR

THEORICAL CONTENTS

Winogradsky columns provide a visual example of various modes of metabolism in the microbial world. When most of us hear the term “biodiversity,” we think of tropical rainforests and coral reefs. But perhaps the most critical biodiversity exists right under our feet: in the microbial world that inhabits our soil and surface waters. The earliest forms of life — microbes — evolved 3.5 billion years ago, and their descendants still shape the ecosystems and evolution of life on Earth. Bacteria and Archaea are not only the oldest life, they are also the most diverse and numerous organisms on Earth. For the first 2 billion years of Earth's history, they were the only living things on the planet. These microorganisms show a surprising diversity in metabolism mechanisms such as: oxygenated and anoxygenic photoautotrophy, chemoautotrophy and photoheterotrophy, to name a few. They also play an essential role in the cycling elements that make the planet habitable for all other types of organisms. The diversity of these simple life forms is evident in the myriad of ecological niches they inhabit, from hydrothermal vents to the acidic lining of the stomach.

In the lab, it’s actually quite challenging to study microbial communities because you have to deal with multiple species, which gets very complicated very quickly. In the late 1800s, the microbiologist Robert Koch figured out how to separate individual species through the pure culture method. He isolated microbes from infections and then tested to see whether they were the causes of the infections. Being able to pinpoint what specific microbe is causing a particular infection is crucial in figuring out how to treat that infection. However, it’s also clear that microbes do not live in isolation. Most of the time, they are together in communities, especially in the body where infections occur but even out in nature in the mud. And so, Sergei Winogradsky wanted to understand microorganisms in their natural habitat, in their natural surroundings, with their natural fellow occupants in competition. In the Winogradsky column, microbes first consume the added organic material while depleting the oxygen in the bottom layers of the column. Once the oxygen is used up, anaerobic organisms can then take over and consume different organic materials. This consecutive development of different microbial communities over time is called succession. Microbial succession is important in a Winogradsky column, where microbial activity changes the chemistry of the sediment, which then affects activity of other microbes and so on. Many microorganisms in soils and sediments also live along gradients, which are transitional zones between two different types of habitats based on the concentrations of substrates. At the correct spot in the gradient, a microbe can receive optimal amounts of substrates. As a Winogradsky column develops, it begins to mimic these natural gradients.

With the mud inside of a clear container, the microbes begin to reveal themselves in different layers of different colors based on the microbes that can grow in those particular layers. Different microbes prefer certain conditions and will or will not grow depending on how much oxygen or light is available at the top versus the bottom.

The interesting part is adding other ingredients like different metals or salts, in order to see how different parameters affect our miniature microbiological ecosystem.

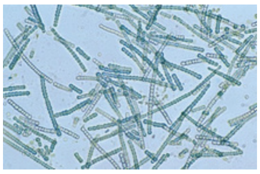
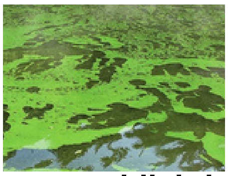
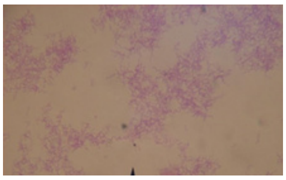
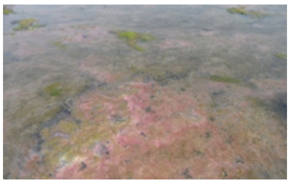
LIFE IN A JAR

EVALUATE AND COMPARE THE BACTERIA FOUND

EXPLAIN + ELABORATE

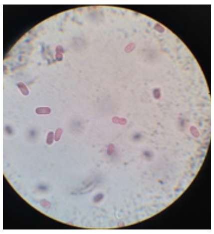
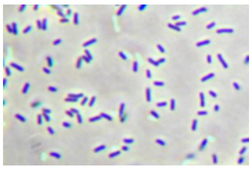
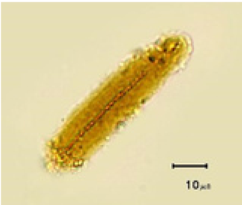
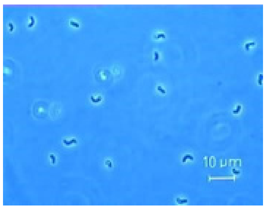
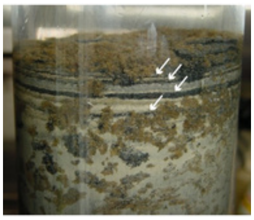
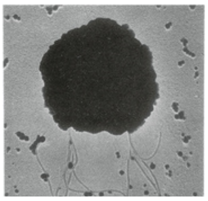
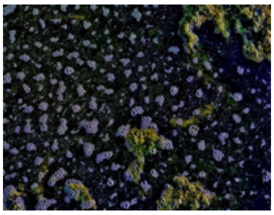
Use both your naked eye and a microscope to recognize your bacterial population, in the following there are two partial guides (a visual and a metabolic one) to recognize and know your species. Check if stratified populations are correlated to elements cycling (es. top bacteria produce something used by bottom bacteria). You can also use a on-line interactive guide to explore a column and the bacteria families that will be more likely to grow in your columns.

TABLE

Position in column	Functional group	Organism Examples (microscope view)	Visual indicator
TOP	**Photosynthesizers**	 **Cyanobacteria**	 **Green or reddish-brown layer. Sometimes bubbles of oxygen.**
	Nonphotosynthetic sulfur oxidizers	 **Beggiatoa, Thiobacilus**	 **White layer**
MIDDLE	**Purple nonsulfur bacteria**	 **Rhodomicrobium, Rhodospirilum, Rhodopseuodmonas**	 **Red, purple, orange, or brown layer**

LIFE IN A JAR

TABLE

Position in column	Functional group	Organism Examples (microscope view)	Visual indicator
MIDDLE	Purple sulfur bacteria	 Chromatium	 Purple, or purple-red layer
	Green sulfur bacteria	 Chlorobium	 Green layer
	Iron-oxidizers Bacteria	 Thiobacillus ferrooxidans, Leptospirillum ferrooxidans, Mariprofundis ferrooxydans	 Red just colour
	Sulfate Reducing Bacteria	 Desulfovibrio, Desulfotomaculum, Desulfobacter, Desulfuromonas	 Black layer
	Methanogens	 Methanococcus, Methanosarcina	 Sometimes bubbles of metane. Deep black color

LIFE IN A JAR

EXPLANATION

Cyanobacteria:

Cyanobacteria are green photosynthetic bacteria that can be found in nearly all environments with light and water including freshwater, marine, and terrestrial habitats. Cyanobacteria are often in competition with the eukaryotic green algae (who are often a brighter emerald-green color), and the two are often heavily mixed. In freshwater habitats cyanobacteria are often army-green, but can also appear as brown/black patches, gooey reddish-orange floating masses, yellow-brown films floating on the water or attached to vegetation.

Sulfide oxidizers:

Sulfide oxidizers are a group of bacteria that eat hydrogen sulfide (H_2S) and breathe oxygen. They live near black sediments rich in hydrogen sulfide. A field mark of sulfide oxidizers is the white scum and fuzz they often produce. They require oxygen and therefore, will not be too deep in the sediment, but may be hidden below the green photosynthetic bacteria and algae. The ideal location for these microbes is where the layers of oxygen rich sediment and anaerobic, hydrogen-sulfide rich sediment meet, such as marine estuaries.

Purple Nonsulfurs:

The purple nonsulfurs can be found in anaerobic environments in the photic zone (the layer of the sediment that sunlight can reach) where they can carry out photosynthesis. Some representatives of this group are very metabolically flexible. These bacteria can be found in marine, fresh, hypersaline, or thermal waters, and are common in temporary puddles in hardwood forests.

Purple Sulfurs:

Purple sulfurs use hydrogen sulfide, light and carbon dioxide to make sugars. Therefore, they thrive in environments that are within the photic zone and are rich in sulfide compounds. These bacteria can be found as a purple-pink layer beneath the green cyanobacteria and in contact with sediments that are sulfide-rich, anaerobic, and black in color.

Green Sulfurs:

Green sulfurs can be seen in anoxic environments that receive light (photic zones) and have high sulfur and low oxygen levels. They can be seen as a thin layer of green beneath the purple bacteria and above a black sediment rich in sulfide.

Iron-oxidizers:

These microbes produce a rust red color, a field mark that appears most often over black sediments. The color is a sign of iron reducers solubilizing solid iron from minerals in the anoxic parts of the sediment.

Sulfate reducers:

Sulfate reducers eat hydrogen and sugars and breathe sulfate. They produce hydrogen sulfide which is the stinky smell in rotten eggs. They form a black layer of sediment below the photic zone especially in marine environments where sulfate from seawater is plentiful.

LIFE IN A JAR

EXPLANATION

Methanogens:

Methanogens are archaea that take in hydrogen, acetate, or a few one-carbon compounds and carbon dioxide and produce the gas methane. They can be found in anoxic environments such as below the surface of stagnant, swampy water. If the sediment is stirred and bubbles of gas come up to the surface, this is a sign of the methane produced by methanogens. The gas does not necessarily smell like sulfur and can be flammable. Sediment rich in methanogens is often a deep black color.

Fermenters:

Fermenters grow without oxygen to produce hydrogen, CO2, and alcohols like ethanol. They are found in the most anaerobic environments including deep in sediment and human guts. Fermenters make the bubbles of CO2 in bread, cheese and beer.

Biofilm formers:

Organisms that eat sugars, carbohydrates, and amino acids and breathe oxygen are called aerobic heterotrophs. Many microbes that are aerobic heterotrophs grow in thick gooey layers called biofilms. Biofilms can cause a big problem industrially and in medicine on medical devices because they form a protective layer around a microbial community and prevent antimicrobials from killing them.

FURTHER INFORMATION

https://www.jove.com/it/v/10506/creating-winogradsky-column-method-to-enrich-microbial-species

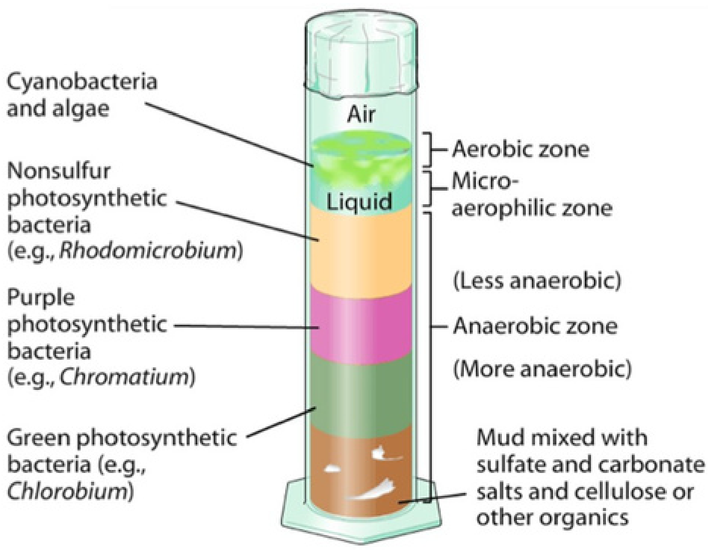
https://publish.illinois.edu/projectmicrobe/files/2015/05/U9_L4_Resource_WinogradskyColumnProtocol.pdf

https://www.researchgate.net/publication/280869603_Temporal_and_Spatial_Distribution_of_the_Microbial_Community_of_Winogradsky_Columns

http://archive.bio.ed.ac.uk/jdeacon/microbes/winograd.htm

https://www.biointeractive.org/sites/default/files/media/file/2019-05/winogradsky.pdf

https://www.biointeractive.org/sites/default/files/winogradsky_teacher.pdf



GLOBAL WARMING IN A BOTTLE

SUBJECT
PHYSICS OF MATTER
THERMODYNAMICS

TOPICS
#CO2
#CLIMATE CHANGE

OBJECTIVES

- Learn what global warming is

- Realize the impact of their lifestyle on the environment

LEARNING SCENARIO

We suggest approaching the experience as a guided inquiry.
The teacher should adjust the level of accuracy and depth in the explanations.
The path is designed for a class of about 20 students. The main experiment can be carried out in a single lesson of 1-2 hours, while the entire course can have a variable duration, involving several lessons, depending on the choices of the teacher.

EXPERIMENT DESCRIPTION

ENGAGE

Introduce students to the problem of climate change, and let them discuss, guiding the discussion with questions, for example: what's happening to Earth's mean temperature? What is the greenhouse effect? Which are its causes? What impact do human beings and their activities have on the environment and specifically on global warming and climate change?

Find and show them data, graphics, photos, videos, news (from reliable and qualified sources). You can for example search in:
https://www.ventusky.com/
https://app.electricitymap.org/map?wind=false&solar=false
https://earth.nullschool.net/
https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases
https://compostrevolution.com.au/
https://climate.nasa.gov/
https://www.ipcc.ch/
https://www.ted.com/talks/gavin_schmidt_the_emergent_patterns_of_climate_change#t-2113
https://www.youtube.com/watch?v=64R2MYUt394

GLOBAL WARMING IN A BOTTLE

EXPERIMENT DESCRIPTION

Engage students by asking them to calculate their direct impact on CO_2 emissions, and their carbon footprint. For example, you can ask them to keep a daily diary and take notes about how many km they travel by car each week and how much fuel they consume on average with those trips (involving their parents in this “data collection”).
And/or you can ask the to take a “food waste diary” like this one:
https://docs.google.com/forms/d/1heqpQzz_JG2OHvEInFixxRYGxY666M-SDuv73xwjhTo/edit

EXPLORE
Split the class into groups and follow the scientific sheet "Global Warming in a bottle".

The teacher will do some of the work but should try to involve students of each group in the realization of the experiment.

Each group must collect data, organize them in a table and draw a temperature vs time graph, during the activities each group should write a diary, and in the group, each task should be assigned in rotation.

Let the class analyze the results of the experiment, discuss with them and try to do a generalization to the atmosphere.

EXPLAIN
Climate change is a very complex matter and the level of depth has to be chosen wisely by the teacher. Depending on the audience you can talk about the interaction between light and matter, the Stefan-Boltzmann law, black body radiation, Wien’s law, the structure of matter, chemistry, thermodynamics and so on. Or you can say, more easily, that the earth receives energy (heat) from the sun and the atmosphere “traps” part of it. This phenomenon is called the “greenhouse effect” (from the french mathematician Fourier) and it’s the main regulator of the earth’s temperature.

Briefly: the increase of CO_2 in the atmosphere contributes to a substantial rise of the greenhouse effect and so in temperature. The molecules that form the atmosphere have different chemical and physical properties, so they react differently to light exposure. Greenhouse gases absorb and emit part of the infrared light that passes through them and so an atmosphere containing a greater amount of them gets hot faster and cold slower, reaching a higher equilibrium temperature.

GLOBAL WARMING IN A BOTTLE

EXPERIMENT DESCRIPTION

For a detailed analysis of the experiment you can see:
https://www.researchgate.net/publication/260295844_%27Climate_change_in_a_shoebox%27_A_critical_review

Clearly, the phenomenon in the atmosphere is different from the one in the bottle, but there is a strong scientific consensus that the greenhouse effect due to carbon dioxide is a main driver of climate change:
The Energy Balance Model
Illustrative model of greenhouse effect on climate change - Wikipedia
Climate Model
The Earth-Atmosphere Energy Balance

ELABORATE

You can engage the students and make them think and talk about the causes and consequences of the greenhouse effect.
They should realize the impact that human society has on Earth and the bad effects that global warming has on our lives and in particular on those living in the most exposed and fragile areas and conditions.

They can be driven to think about some big actual environmental problems like:

- rising temperatures in the sea, effects on chemical-physical properties and on ecosystems, rising in sea level (thermal expansion);
- melting and loss of arctic ice and mountain glaciers and consequent rising of the level of the oceans (with all the connected environmental and social problems);
- the effect of rising temperatures on the convective currents and in particular on the “great conveyor belt” and the consequences for ecosystems: https://youtu.be/jOVvXDI0KbY; https://www.ted.com/talks/jennifer_verduin_how_do_ocean_currents_work?utm_campaign=tedspread&utm_medium=referral&utm_source=tedcomshare
- the effect of rising temperature in atmosphere on the frequency of droughts, hurricanes, storms and other extreme weather events.

All these activities can be done with an inquiry and hands-on approach: with easy experiments we can show and study thermal expansion of water (Swelling Seas: Ocean and Environmental Science Activity | Exploratorium Teacher Institute Project), convection (Convection Current Demonstration - Bing video), thermal energy and temperature (Thermal Energy 1.1: Temperature Experiment Video - YouTube).

GLOBAL WARMING IN A BOTTLE

EXPERIMENT DESCRIPTION

The class can also observe carbon dioxide production in some simple ways, with hands-on experiments:

- inflating a balloon placed on the top of a bottle, by mixing vinegar and sodium bicarbonate in the bottle (chemical reaction) https://www.youtube.com/watch?v=T29OYbFrTgU
- inflating the balloon by mixing water, yeast and sugar (anaerobic fermentation) https://www.youtube.com/watch?v=Cv-b0NdHZfs
- observing a candle that goes out under a jar (combustion) https://www.youtube.com/watch?v=68O2Ea-hUsE
- measuring the co2 produced by their breathing, using a co2-meter, in the classroom, first keeping the windows open and then closed for 15-20 minutes.

In respect to the experiments above, note that it is a common notion that breathing and combustion emit CO2, while if we do not have a carbon dioxide meter available, then we will not be able to experimentally prove that the "air" in the balloon is really CO2. However we and the class can reasonably assume that this is true (actually we know it is true): we can observe that the air in the balloon can be poured into a glass and then over a candle, extinguishing it, just like the air in the jar. Remember: this is the same way we used to prove the presence of CO2 in the main experiment (there we used an inflamed stick).

The class should reflect on human CO2-emissions and their impact on climate, the carbon cycle (https://www.youtube.com/watch?v=KNLUzqW8IuA), the role of factories and industries, combustion and energy production, waste of food and goods, extractivism, intensive farming and fishing.

Students could try to calculate their personal carbon footprint (the amount of co2 they produce every year, https://www.carbonfootprint.com/calculator.aspx) or the one of their class, or their town/country. They are encouraged to discuss, analyze and propose individual and collective-social solutions and remedies to the co2-problem, to think (and “count”) “what can we do to reduce emissions? Which concrete actions? How many times?”

The class could also do a historic research and find that the first scientist who discovered and explained the greenhouse effect due to CO2 was Eunice Newton Foote, an American scientist and feminist activist whose contribution to climate sciences was forgotten for a lot of time:
https://en.wikipedia.org/wiki/Eunice_Newton_Foote
https://www.searchanddiscovery.com/pdfz/documents/2011/70092sorenson/ndx_sorenson.pdf.html

GLOBAL WARMING IN A BOTTLE

EXPERIMENT DESCRIPTION

They can search the web and collect data, graphs, images, and videos.
Great sources are:
https://climate.nasa.gov/ (look for: images of change & interactives!)
https://www.ipcc.ch/ (read the reports!)

In bibliographic research and on the web, students are encouraged to verify the reliability of sources and to look for facts and evidence that prove (or disprove) their hypothesis (or biases), and to describe "quantitatively" (i.e. with numbers, models, graphs, etc.) causes and consequences of climate change.

Finally, we can use all these things to develop calculus and math.
For example https://spacemath.gsfc.nasa.gov/SMBooks/SMEarthV2.pdf

EVALUATE

We promote peer-evaluation and self-evaluation (for the individuals and the groups, the teams).
Teacher evaluation - formulate questions that are related to the work students did.
You can use the link above to propose applied math problems to the class.
You can ask the student to think about useful ways to change their personal and collective behaviours in order to reduce the carbon impact of the society they live in. They can write their proposals and print a document to spread it in the school, to their parents, friends, and so on. They can write a paper or a journal, or draw a poster, or make a podcast or a video. Or they can do all these things (and/or others, it depends on time).
The teacher can organize with the class a scientific exhibit, with graphic and video materials, performances, experiments done by students, and so on. In this way, students have the chance to become science communicators and test their skills.

OCEAN ACIDIFICATION

SUBJECT
CHEMISTRY
BIOLOGY

TOPICS
#PH #CARBONATES AND ACIDS
#METALS AND NON-METALS
#ECOSYSTEMS #HOMEOSTASIS #EVOLUTION

OBJECTIVES

- Understand how the level of carbon dioxide in the atmosphere affects the pH of the oceans
- Learn to measure and compare the pH of different solutions
- Learn to collect qualitative and quantitative data

LEARNING SCENARIO

Groups: groups of 3 students

Time needed: 60 minutes but the discussion can take as much as needed/chosen

EXPERIMENT DESCRIPTION

ENGAGE

Students generate questions stimulated by teacher proposed pictures/videos and/or Discussion on teacher proposed questions and/or Discussion on teacher proposed facts.

Examples:

CO2 increase (Nasa maps and graphs)
PH changes map
Diving in a bleached coral reef

Netflix documentary/series:
My Octopus Teacher
Blue Planet

Eventually, we target questions like:

How is acidification happening?
Is there any causal link between increase of CO_2 in atmosphere and increase of acidity in seas, lakes, oceans?

Students will be asked to set up their own method to investigate these questions.

BOOSTING GREEN EDUCATION

OCEAN ACIDIFICATION

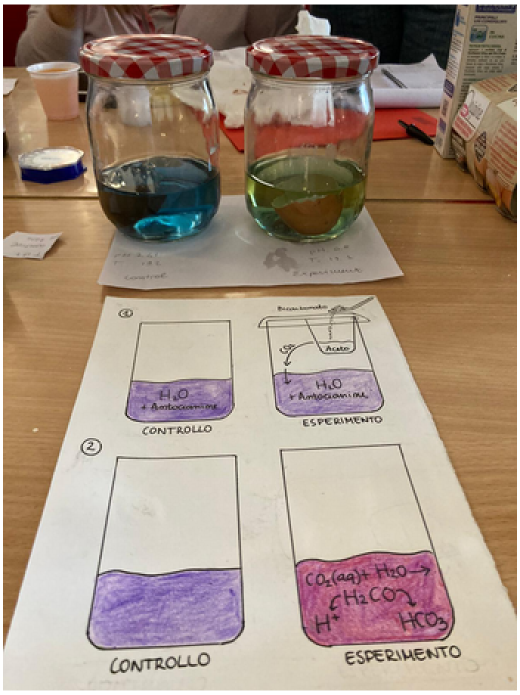
EXPERIMENT DESCRIPTION

EXPLORE

Students are given equipment and background information if needed (how to produce CO2, how the indicator works etc.). The amount of information and support will strongly depend on what students already know.

They are then asked to design the experiment to explore if there is a causal correlation.

Teachers will ask further questions to point out problems with their procedure (e.g. no control) and invite them to develop it.



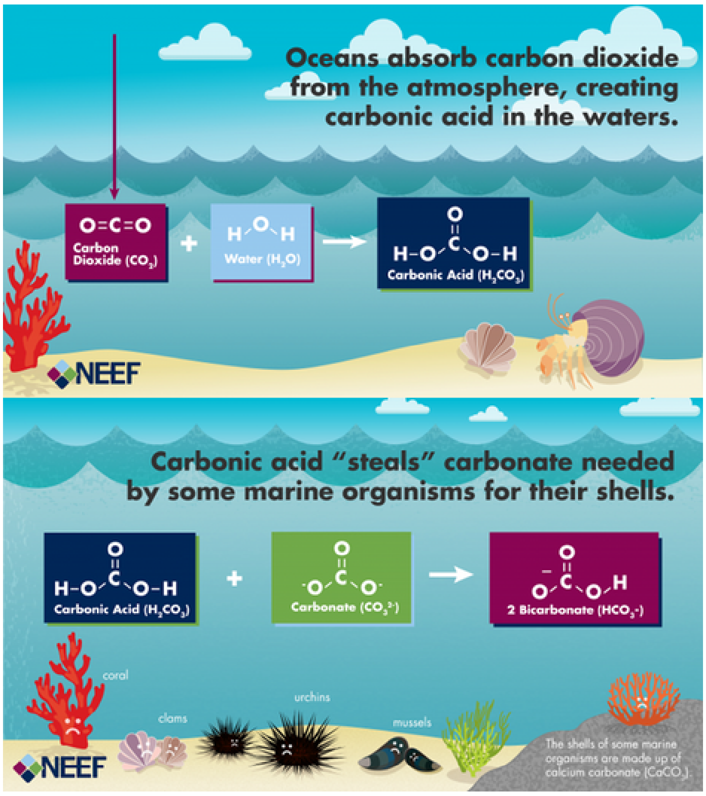
EXPLAIN

https://ocean.si.edu/ocean-life/invertebrates/ocean-acidification

Students are then given the internet back and carry out research to look for explanations: how does CO2 make water acidic?

They compare information they found and discuss their sources among different groups.

They present their explanation in a visual way (role-play, object, model).



OCEAN ACIDIFICATION

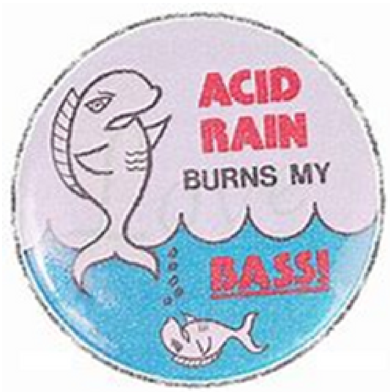
EXPERIMENT DESCRIPTION

ELABORATE

Ask them how far this is a good model for real oceans/ explore what the differences are.
Other types of water pollution.
Small changes and big impacts on ecosystems.
Further experiments about how acids affect living things.
Impact on people.
Why should we care? Why is it important? Expand to philosophy.
Expand Chemistry (pH, H+, logarithm etc.).
Are there hypotheses or predictions available?
Is there a solution? Are these changes reversible? How far?
Ask them how far this is a good model for real oceans/ explore what the differences are.
Fake news and real news (enzymes, homeostasis) about acidity and health.

EVALUATE

Use of models in Science.
Rubric to assess on process, effectiveness and collaboration.
Rubric to assess their presentation on the explanation.



WATER POLLUTION

SUBJECT

CHEMISTRY
BIOLOGY

TOPICS

#WATER POLLUTION #DRINKING #WATER SAFETY #WATER QUALITY PARAMETERS #FILTRATION SYSTEMS

OBJECTIVES

- Learn more about water pollution
- Learn how to compare different water purification methods
- Learn how to obtain safe drinking water
- Know the catastrophic effects of water pollution

LEARNING SCENARIO

3 desks combined to form an "isle", for each isle 4-5 students in a group of work, 4-5 groups working on the same subject and comparing methods,data and results.
If the class is not accustomed to work by the inquiry approach, we suggest starting from a partial "structured inquiry" scheme, in which the procedure is given by the teacher.

EXPERIMENT DESCRIPTION

ENGAGE

Starting from these links ("water pollution sources") we show on the web pictures, videos, articles, advertisements, public speeches of environmental activists. Natural and environmental disasters (especially if happened nearby or known by the local community) are good ways to catch attention and to stress that the subject is very serious, concerning and important.

Human Health and Ocean Pollution

https://annalsofglobalhealth.org/article/10.5334/aogh.2831/

Boundary Currents

https://oceanservice.noaa.gov/education/tutorial_currents/04currents3.html

Google image search results of "Water Pollution"

https://assets.nrdc.org/sites/default/files/styles/full_content--retina/public/media-uploads/guide_waterpollution_66615937_2400.jpg?itok=l7kar9Ev

https://www.history.com/.image/t_share/MTU3ODc5MDg1NjI5OTA4Mjk3/nature-pollution.jpg

Exxon Valdez oil spill

http://news.bbc.co.uk/1/hi/world/americas/298608.stm

Mar Menor: Tonnes of dead fish wash up on Spanish lagoon's shores

https://www.bbc.com/news/world-europe-58311105

DIY Salt-Water Survival Bottle

https://www.youtube.com/watch?v=PT6cjp_zThw

WATER POLLUTION

EXPERIMENT DESCRIPTION

Top 6 causes of water pollution
www.novatx.com

- Rapid Urban Environment
- Improper Sewage Disposal
- Fertilizer Run-Off
- Oil Spills
- Chemical Waste Dumping
- Radioactive Waste Discharge

Job opportunities
https://uk.indeed.com/Water-Treatment-jobs?vjk=c72d8c426070e2ad
What are the causes of water pollution?
https://online.ecok.edu/articles/causes-of-water-pollution/

Talking to the students, we make them think about what is drinkable/not drinkable water and the parameters used to define it. We can show a label of a water bottle. We can talk about the possible use of non-drinkable water, as used in agriculture.

Then we can reflect on purifying dirty water, pointing out some of these open questions:

- How can we clean up dirty water from a WC?
- What is different in WC-water before and after use?
- Why can't we drink sea water? Is it possible, and how, to make seawater drinkable?
- How many ways do you know to purify water?

EXPLORE
Referring to the **technical sheet "Water Pollution"** we run the experiment. As a structured inquiry, we can just show how to assemble a filter and the order of the different steps, or (going a little deeper in IBSE approach) we could just show materials and let the student find the way to assemble the filter and the sequence of the steps (first mechanical- then chemical).
Then we make different tests and collect datas. It is important to make the students think about the fundamental parameters of a mechanical filter and consequences of adding chemicals to water.

WATER POLLUTION

EXPERIMENT DESCRIPTION

EXPLAIN

Comparing collected data and collective debate to make emerge a specific pathway to purify water. Referring to literature (filtering models, as the law of Darcy) we try to “read” these formulas trying to understand every variable in it. Also, we compare our model (just elaborated analyzing our data) with already existing models.

Just as a suggestion, we could refer to this free link about Theories of filtration: https://magadhuniversity.ac.in/download/econtent/pdf/Filtration_Theory%20and%20Factors%20affecting_Pharm%20Eng%20I.pdf

ELABORATE

To fix concepts, enlarge comprehension, make links with previous knowledge or with other subjects, practice and integrate the freshly learned models, we could follow these strategies:

- make exercises (also as homework) with the theories of filtration used in the explained stage
- make individual or group research (also as homework) on related topics following the guidelines used in the step of “Engage”: articles, natural events, environmental accidents, working processes (for example in the food processing industry or in the water depuration city plants), strange now-understandable phenomena, everyday experiences (for example parameters used in the swimming-pools for adding chemicals, filtering of the coffee, etc.)
- collective debate on environmental problems (better if local) and their possible resolution
- generally, we could take all the materials collected in the phase of “Engage” and read them again with a deeper comprehension
- public explanation of the models and theories discovered in a divulgation speech or workshop
- elaboration of future steps of exploring and studying
- make links with other subjects as:

- geography (differences between sea and lakes, polluted and not polluted sites, water sources, etc.)

- biology (water related microorganism such as virus, bacteria, consequent diseases)

chemistry (mixing chemicals)

- environmental education (economy- health – environment, concept of Global Health)

WATER POLLUTION

EXPERIMENT DESCRIPTION

EVALUATE

Students have to evaluate their work as groups, concentrating on right and wrong choices in the exploration phase, strategies to make the whole process faster, and optimizing the whole process.

Teachers can evaluate both groups and single students by considering homework and researches, the divulgation speeches, and attainment during the whole process.

The bad and not-so-good evaluations could be improved by the students through additional efforts (make a new research, elaborate a new protocol, review your homework, etc.).

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Annex - the IBSE method and activity sheets based on IBSE

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